Aug. 31, 1943. E. CANNON 2,328,258

APPARATUS FOR CONTROLLING THE SLIDE MOVEMENT IN LONG-BED HYDRAULIC PRESSES.

Filed Sept. 26, 1942 3 Sheets-Sheet 1

Fig-2

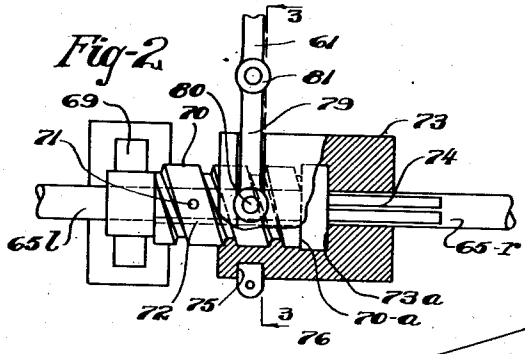
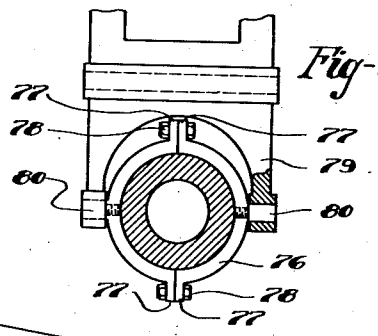


Fig-3



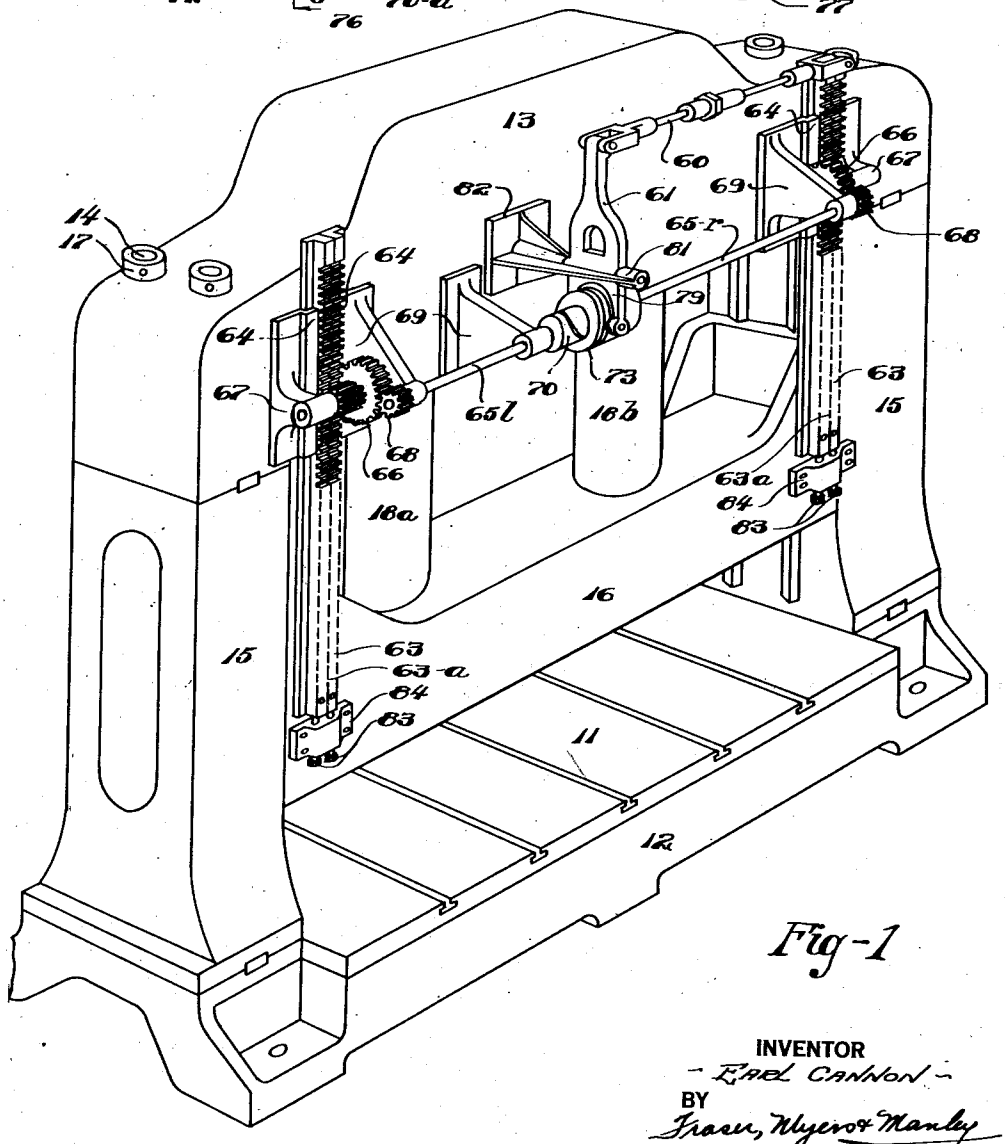


Fig-1

INVENTOR
- Earl Cannon -
BY
Fraser, Myers & Manley
ATTORNEY

Aug. 31, 1943. E. CANNON 2,328,258

APPARATUS FOR CONTROLLING THE SLIDE MOVEMENT IN LONG-BED HYDRAULIC PRESSES

Filed Sept. 26, 1942 3 Sheets-Sheet 2

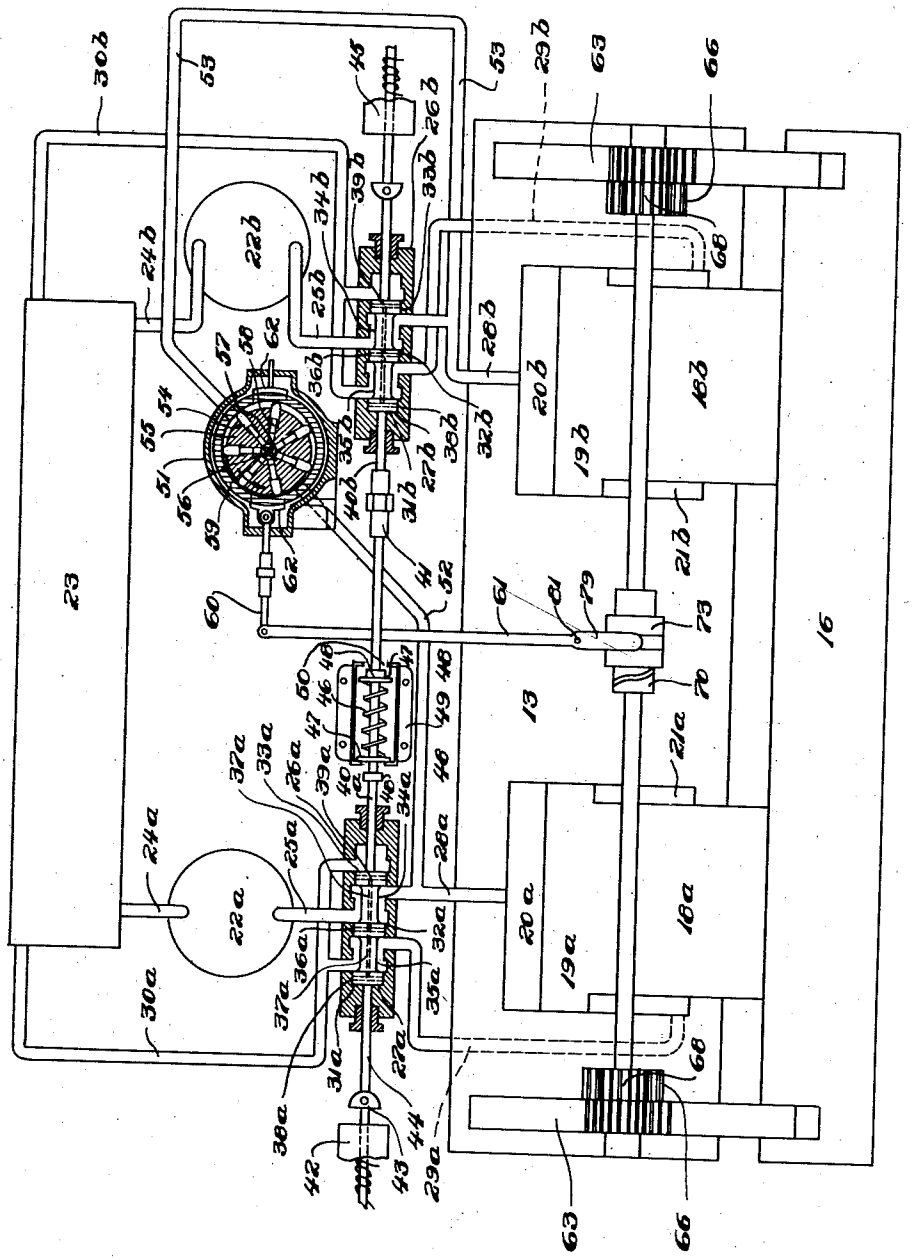


Fig. 4

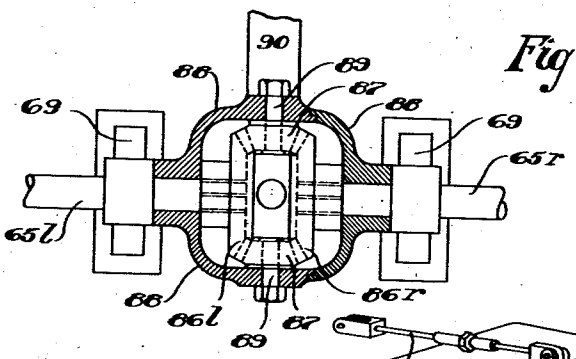
INVENTOR
EARL CANNON
BY
Fraser, Myers & Manley
ATTORNEY

Aug. 31, 1943. E. CANNON 2,328,258

APPARATUS FOR CONTROLLING THE SLIDE MOVEMENT IN LONG-BED HYDRAULIC PRESSES

Filed Sept. 26, 1942 3 Sheets-Sheet 3

Fig-6



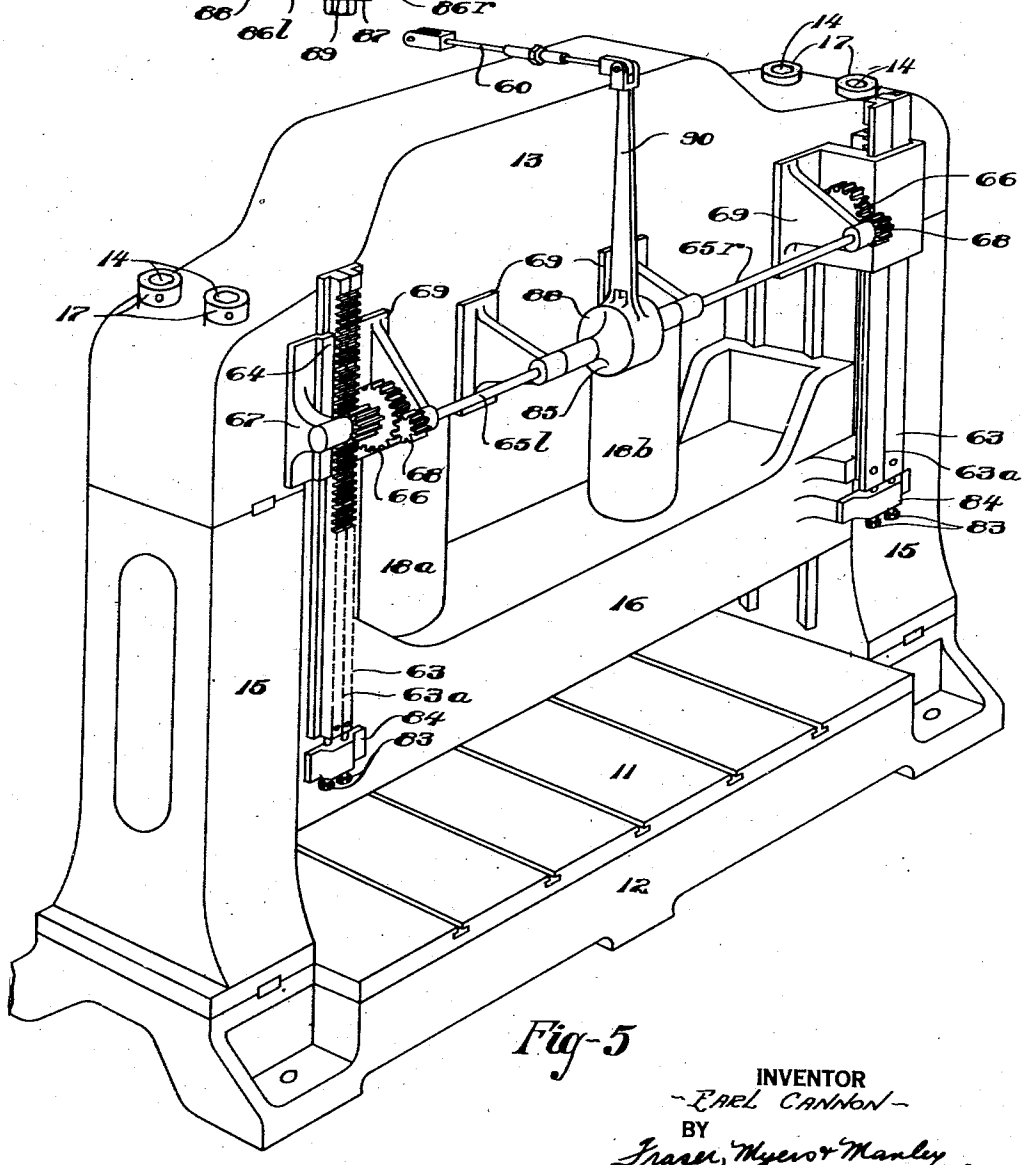


Fig-5

INVENTOR
-EARL CANNON-
BY
Fraser, Myers & Manley
ATTORNEY

Patented Aug. 31, 1943

2,328,258

UNITED STATES PATENT OFFICE

2,328,258

APPARATUS FOR CONTROLLING THE SLIDE MOVEMENT IN LONG-BED HYDRAULIC PRESSES

Earl Cannon, Rockville Centre, N. Y., assignor to E. W. Bliss Company, New York, N. Y., a corporation of Delaware

Application September 26, 1942, Serial No. 459,854

9 Claims. (Cl. 100—71)

This invention relates to a method and apparatus for controlling the slide movement in long-bed hydraulic presses.

Experience has shown that, for many purposes, hydraulic presses are preferable over mechanical presses. This preference arises, among other considerations, from the readiness with which a hydraulic press may be adjusted to vary either the length of its advance stroke or the pressure which said stroke may cause to be imposed upon the material or blank being pressed (hereinafter referred to as a "blank").

It is often desirable, however, to provide a press in which the press bed and slide are relatively long as compared to their respective widths. Such parts, for example, may be two or more times as long as they are wide. In mechanical presses having such long slides, the opposite ends of the latter are commonly connected to and operated by similar crank arrangements. In some such presses one crank is employed at each end of the slide and in others a pair of cranks is employed at each end thereof. In any event, the mentioned crank arrangements are usually so designed that the press slide is constrained, by its actuating means, to remain substantially parallel with the bed of the press during its advance stroke, even though the shape of the die or dies or the nature of the material being processed is such that the pressing reaction is centered at a point substantially to one side or the other of the center of the slide. While possessing the advantages just mentioned, with respect to parallelism of the slide and bed, such long-bed mechanical presses, nevertheless, lack the facility for ready adjustment of the advance stroke which, as heretofore remarked, may easily be provided in hydraulic presses.

Difficulties have been experienced, however, in providing a long-bed hydraulic press adapted for handling relatively high pressures and having commercially practicable means for maintaining substantial parallelism between the press slide and bed. If, for example, a single hydraulic ram is employed at the center of a long press slide, any inequality in the resistance opposing the advance of the slide, toward opposite ends thereof, induces or strongly tends to induce, tilting or cocking of the slide during the working portion of its advance stroke. The mentioned inequality may arise, among other conditions, from differences in the vertical dimensions of the die toward opposite ends of the slide or from variations in the thickness of the blank. Efforts have been made to obviate this difficulty, in long-bed hydraulic presses, by providing two or more rams along the length of the slide and by providing separate pumping systems, theoretically identical, for charging liquid into the several advance stroke chambers operating said rams. It has been found practically impossible, however, to attain uniform functioning of such separate pumping systems during the advance stroke of a press, largely because of different slippages encountered in pumps in such systems under the unequal pressures to which they are subjected. Attempts, heretofore made, to effect compensation for such non-uniform operation, directly in the said pumping systems, have occasioned a sacrifice in efficiency inasmuch as such compensation necessarily involved operating one or both pumping systems below full capacity. Hence, theoretically identical pumping systems, as heretofore employed, have failed to accomplish the desired objectives efficiently.

It may be considered that a hydraulic press could be constructed in which the slide guides, the slide housing, and possibly other parts of the press could be made large and strong enough to maintain the desired parallelism by sheer force. Such an expedient would render the hydraulic press so much larger than mechanical presses for similar purposes, that the hydraulic press would be commercially unacceptable. In addition to the objectionable size of such a press, the wear on the various working parts would be excessive and frequent adjustments and replacement of worn parts would be necessary.

It should be understood that the term "long-bed," when employed in this specification with reference to hydraulic presses, refers to any hydraulic press wherein the present invention may be employed advantageously to maintain, substantially, the mentioned parallelism of the slide and bed of the press.

An important object of the present invention is the provision of improved means for so controlling the distribution of liquid to ram advance chambers actuating a plurality of rams in a long-bed hydraulic press that the press slide, during its advance stroke, is maintained in substantial parallelism relatively to the press bed.

Another object of this invention is the provision of a long-bed hydraulic press, the functioning of which compares favorably with the functioning of a mechanical press designed for a similar purpose, while at the same time yielding the mentioned advantages of ease of adjustment of the length or pressure of the advance stroke of the press.

The foregoing and other objects are accomplished according to this invention, generally, by providing, in a long-bed hydraulic press, two or more rams, arranged substantially symmetrically along the length of the press slide, for operating the latter; by providing separate substantially identical pumping systems for operating each of said rams or for operating rams or groups of rams adapted to apply working force to the slide toward opposite ends thereof; by providing means for compensating for differences in the volume of liquid pumped to the mentioned rams; and by providing means, controlled by relatively slight differences in advance movement of opposite ends of the press slide, for automatically controlling the said compensating means whereby to vary the volumes applied to the several said rams to an extent which substantially compensates for the uneven distribution of flow to the rams from said pumping systems due to the varying resistance offered to the advance of the slide by the die or the blank.

For the purpose of illustrating the present invention and without limiting the invention thereto, several embodiments thereof are shown in the accompanying drawings, in which:

Figure 1 is a perspective view of a preferred embodiment of the present invention (hereinafter referred to as the "first" embodiment) and of a long-bed press on which it may be employed.

Fig. 2 is a detail view, partly in section and partly in elevation, of a screw and nut assembly which is employed in the said first embodiment as a means, responsive to differences of advance movements of opposite sides of the press slide, for actuating a pump adjusting device.

Fig. 3 is a sectional view of the mentioned screw and nut assembly, the section being on the line 3—3 of Fig. 2.

Fig. 4 is a diagram illustrating the operation of the said first embodiment of the invention.

Fig. 5 is a perspective view, similar in character to Fig. 1, of another embodiment of the invention (hereinafter referred to as the "second" embodiment), and

Fig. 6 is a detail view, partly in section and partly in elevation, of a differential assembly which is employed in the said second embodiment as a means, responsive to differences of advance movements of opposite sides of the press slide, for actuating a pump adjusting device.

Further improved means for attaining the objects of the present invention are described and illustrated in my application for patent filed October 28, 1942, under Serial No. 463,604.

Referring first to the disclosures of Figs. 1–4, the press with which the first embodiment is illustrated may comprise a long-bed 11 provided in a base 12 suitably tied at its opposite ends to a crown 13 by tie rods 14 extending through slide housings 15 which serve at least partially to guide a vertically reciprocating slide 16 and to suitably space apart the said crown and bed and maintain the two latter members fixedly in their proper relationship. Tie rod nuts 17 preferably are provided at the upper and lower ends (the latter are not visible in the drawings) of the said tie rods.

The slide 16 is reciprocated in a well-understood manner, by rams 18*a* and 18*b*, fixed symmetrically upon the slide, toward opposite ends thereof. These rams, as best understood from Fig. 4, may be enlarged at their upper ends to form ram pistons 19*a*, 19*b* and may be urged downwardly on their advance strokes by liquid introduced into advance chambers 20*a*, 20*b*, and upwardly on their return strokes by liquid introduced into return chambers 21*a*, 21*b*. The said chambers, of the general character indicated in Fig. 4, may, of course, be suitably formed within the crown 13 of the press.

Separate, substantially identical pumping systems are provided for handling the supply of liquid for operating each of the rams 18*a* and 18*b*. Describing in detail, only the said pumping system which is related to ram 18*a*, it comprises a continuously-acting pump 22*a*, suitably driven as by an electric motor (not shown). The said pump receives liquid from a supply tank 23 through pipe 24*a* and pumps said liquid through pipe 25*a* into a distributing slide valve 26*a* which, depending upon the position of a piston 27*a* therewithin, directs the liquid either through a pipe 28*a* to the ram advance chamber 20*a* to move the ram 18*a* downwardly or through a pipe 29*a* to the ram return chamber 21*a* to move the said ram upwardly, or, through a pipe 30*a*, back to the tank 23, when it is desired that the ram remain substantially at rest. The mentioned liquid distribution, yielding the said ram movements, is controlled largely by the provision on the piston 27*a* of three enlarged portions or spools 31*a*, 32*a* and 33*a* and intervening neck portions 34*a* and 35*a*.

When it is desired to advance the ram 18*a* (i. e., move it downwardly) to advance the slide 16 toward the bed 11 and a die and blank thereon, the piston 27*a* is shifted, by any suitable means, to its extreme left position as shown in Fig. 4, whereupon liquid entering the valve 26*a*, through pipe 25*a*, passes around neck portion 34*a*, of the said piston, into pipe 28*a*, and thence to the ram advance chamber 20*a*, thereby forcing the ram 18*a* downwardly while liquid is exhausted from the ram return chamber 21*a* through pipe 29*a* into the valve 26*a*, wherein the exhaust liquid passes around neck 35*a* of said piston to pipe 30*a* which carries it to the tank 23. By shifting the piston 27*a*, to its extreme right position, the flow of liquid is reversed with respect to the said ram chambers thereby causing the ram 18*a* to pursue its upward or return movement.

When it is desired to arrest the movement of the ram 18*a*, the piston 27*a*, may be moved to its mid-position, in which the several mentioned spools on said piston close off all liquid communication between the pump 22*a* and the ram chambers 20*a* and 21*a*. However, the liquid, continuing to be discharged by the pump 22*a* passes from pipe 25*a* into interior lateral passage 36*a* in the spool 32*a*, thence through longitudinal passage 37*a* into lateral passages 38*a*, 39*a* in the spools 31*a* and 33*a*, whence said liquid passes into pipe 30*a* which carries it to the tank 23.

In view of the similarity of the pumping systems for actuating the two rams, the foregoing description is intended to suffice for both. For this reason, the similar parts of the pumping systems are given reference characters, in the drawings and hereinafter in the specification, differing only in their suffixes, the suffix *a* being applied to parts of the pumping system related to ram 18*a* and the suffix *b* being applied to parts of the pumping system related to ram 18*b*. Both valves 26*a* and 26*b* function alike and may be constrained to function in unison by having their respective pistons tied together by extension rods 40*a* and 40*b* which preferably are adjustably coupled by a turnbuckle 41. The said pistons

may be shifted within their respective valves by any suitable means to control the reciprocation of the press slide. Such means, for example, may be operated manually, electrically, by compressed air, or by hydraulic pressure.

As illustrated in the accompanying drawings, an electric solenoid **42** may suitably be connected as by a pin **43** to an end extension **44** of the piston **27***a*. The said solenoid is adapted, when energized, to move the pistons **27***a* and **27***b* to their left positions, as shown in the drawings, to cause downward movement of the press slide **16**. Another solenoid **45** may be similarly connected to the piston **27***b* for moving both pistons to their right positions to cause upward movement of the press slide. The two said solenoids, of course, are connected in suitable electric circuits for controlling the operation of the press.

The pistons **27***a*, **27***b* may be held yieldably in their mid-positions by any suitable means which, for example, may employ springs or air or hydraulic pressure. As illustrated in the accompanying drawings, a spring centering device is employed comprising a coil spring **46** which is positioned about the extension rod **40***a* and is compressed between washers **47** which, normally, are held against the end of said spring by collars **48** formed on or fixed on the rod **40***a*. A cage-like frame **49** is fixed upon some fixed part of the press or other suitable fixed support in such position, adjacent the rod **40***a*, that the latter passes through holes **50** in the ends of said frame, large enough to freely pass the said collars but small enough to confine the washers **47** within the said frame. Thus, when the pistons **27***a* and **27**b are held in their left positions, as illustrated in the drawings, by the energized solenoid **42**, the spring **46** is exerting compression upon the right washer **47** and the right collar **48** which, when the said solenoid is de-energized, will cause the said pistons to move to their mid-positions. A similar, but opposite action of the centering device results when the said pistons are held in their right position by the solenoid **45** and the latter is then de-energized.

Although the pumping systems for operating the rams **18***a* and **18***b*, as thus far described in detail, may be substantially identical in design, it will be appreciated that, where resistance to the advance of the slide is not uniformly distributed thereover, the different slippages in the two pumps, slight leakages, and possibly other factors, would cause the side or end of the press slide encountering the least resistance to advance ahead of the other side thereof and this uneven advance or cocking of the slide, in many instances, would become more pronounced as the slide progressed toward the end of its advance stroke. This highly undesirable functioning of the press may be substantially obviated by compensating means now to be described in detail.

An important feature of this invention is the provision of automatically controllable means for substantially equalizing the supply of liquid to the hydraulic chambers of the several rams which actuate the press slide. It is preferred to provide such means comprising a compensator pump **51**, connected by a pipe **52** to the pipe **28***a*, which carries the liquid supply to ram advance chamber **20***a*, and connected by a pipe **53** to the pipe **28***b* which carries the liquid supply to ram advance chamber **20***b*.

The compensator pump **51** may be of the type, known as the "Hele-Shaw" type, which, as shown in Fig. 4, has a plurality of radially arranged cylinders **54** formed in a rotor **55** suitably driven continuously by a motor (not shown). The inner ends of said cylinders open into an axial bore in the rotor **55** and each of said cylinders, as the said rotor revolves, communicates alternately with ports **56**, which are in liquid communication with the pipe **53**, and with ports **57**, which are in liquid communication with the pipe **52**

Pistons **58** are accurately fitted for reciprocation within and toward the outer ends of the cylinders **54** and are yieldably urged outwardly by springs or other suitable means (not shown) against a confining ring **59** which is so mounted within the frame of the compensator pump as to be capable of sliding movement laterally of the axis of the rotor **55** of said pump, from one extreme position of eccentricity, through a position of concentricity, to an opposite position of eccentricity, and vice versa. The interior diameter of the ring **59**, of course, is materially greater than the diameter of the rotor **55** in order to permit the mentioned sliding movement of the ring. The said sliding movement may be effected by means of a turnbuckle-link **60**, suitably connected between the pipe **59** and a lever **61** which may be actuated by means hereinafter described. If desired, the ring **59** may be mounted so as to be free to rotate, whereby to minimize the friction between its inner surface and the pistons **58** which work thereon, by mounting said ring within a frame **62** and by connecting the link **60** to said frame.

The means by which the lever **61** is actuated to control the sliding movement of the ring **59** and, the resulting operation of the compensator pump, comprises a pair of vertically disposed racks **63** (see Fig. 1), secured at their lower ends to the slide **16** toward opposite ends thereof. The said racks may be guided within suitable guides **64** fixed upon the crown **13**, and when the slide reciprocates, the racks rotate shafts **65***l* and **65***r* in common directions through the medium of step-up gears **66**, suitably journaled upon brackets **67**, which gears drive pinions **68**, keyed upon the outer ends of the shafts **65***l* and **65***r*. The two mentioned shafts are supported within brackets **69** fixed upon the crown **13**. The bearings provided for said shafts in the mentioned brackets should be such as to prevent any material longitudinal movement of the shafts.

A screw **70**, as best understood from Fig. 2, is fixed upon the inner end of shaft **65***l* against any possible movement relatively to the latter, as by a pin **71**, and additionally, if desired, by a key **72**. An elongated nut **73** is slidably mounted upon the inner end of shaft **65***r* as by a spline **74** and when the apparatus is assembled, the nut **73** and the screw **70** are partly screwed together so that their threads are in effective engagement and so that the end **70***a* of the screw **70** and an opposed inner surface **73***a* of the nut **73** are sufficiently spaced to permit sliding movement of the said nut toward the left as well as toward the right.

The nut **73**, preferably, is provided with an exterior annular recess **75** to accommodate a ring **76** which, to permit assembly, may be formed in halves having opposed end flanges **77** held together by bolts **78**. The ring **76**, of course, is constrained to follow any longitudinal movement of the nut **73** and such longitudinal movement may be transmitted to the lever **61** by forming the lower end of the latter as a yoke **79** and pivotally securing the lower ends of said yoke to the ring **76** by studs **80** passing through suitable

bearings in said lower ends of the yoke and screwed into opposite sides of said ring.

The lever 61 preferably is pivoted, at an intermediate point 81, upon a bracket 82 fixed upon the crown 13 of the press. The relative lengths of the arms of the lever 61, as shown in Figs. 1 and 4, are not intended to be controlling, for it should be obvious that the said lengths, in practice, will be determined with reference to the magnitude of sliding movement to be imparted to the ring 59 and to the various other mechanical factors in the structure which give rise to such movement.

The racks 63 preferably are split longitudinally as indicated at 63a and the two parts of each rack are capable of relative longitudinal adjustment through the medium of suitable adjusting screws 83 carried by brackets 84 fixed upon the slide 16. By suitable adjustment of the screws 83, the parts of the racks 63 may be slightly shifted longitudinally relatively to each other whereby to eliminate all material lost motion between the teeth of said racks and the teeth of the step-up gears 66.

In practice, the parts of the described apparatus are so assembled that, when the slide 16 and the bed 11 are perfectly parallel, the screw 70 and the nut 73 are in such relative longitudinal positions that the ring 59 is held in concentric position with respect to the rotor 55 of the compensator pump. When the ring is in the mentioned concentric position the pistons 58, during the continuous rotation of said rotor, follow the concentricity of the said ring and, hence, do not slide within their respective cylinders 54, and, as a result, the compensator pump, although being driven by its operating motor, yields no pumping action whatever. If, during the descent of the slide 16, the latter remains in parallelism with the bed of the press, and, hence, requires no compensating corrections, the ring 59 remains in concentric position and the compensator pump continues inactive in so far as pumping is concerned.

On the other hand, if the ram in its descent, encounters greater resistance toward its right end, caused, for example, by an irregularly shaped die, the liquid slippage in the pump 22b, in the face of such greater resistance, becomes greater than the slippage in the pump 22a and, hence, more liquid is charged into cylinder 20a than into cylinder 20b. This inequality in liquid distribution causes the left side of the slide to tend to descend somewhat in advance of the right side thereof. However, immediately upon the inception of such uneven descent and before the cocking of the press slide becomes objectionable in any practical sense, the shaft 65l and the screw 70 thereon rotate ahead of shaft 65r and the nut 73 thereon, causing the said nut to screw somewhat further onto the said screw. The resultant movement of the nut 73 toward the left actuates the lever 61 and shifts the ring 59 toward the right to the eccentric position indicated in Fig. 4.

When the ring 59 is in the mentioned eccentric position shown in Fig. 4, and assuming that the rotor 55 is continuously driven in a counter-clockwise direction as indicated by the arrow, the pistons 58, during the lower half of their circular travel within the ring 59, are moving outwardly within their respective cylinders 54 and, hence, are drawing liquid into said cylinders, through the ports 57, from the pipes 52 and 28a. The liquid thus drawn into said cylinders, is discharged therefrom through the ports 56 into the pipes 53 and 28b, during the upper half of the circular travel of said pistons within the ring 59 by reason of the fact that, during that period, the pistons are being forced inwardly within their respective cylinders 54 by the said ring.

It should be understood, from the preceding paragraph that the described action of the compensator pump 51 operates to draw liquid from the pipe 28a, supplying liquid to chamber 20a, and transfer it to pipe 28b, supplying chamber 20b. This transfer of liquid continues until it compensates for the inequalities in liquid delivery caused by the unequal distribution of the resistance opposing the descent of the slide and until the parallelism of the slide and bed of the press is restored. When said parallelism is restored, the nut 73 will have been restored to its normal setting and the ring 59 will resume its concentric position, thus discontinuing the pumping action of the compensator pump.

The degree of eccentricity imparted to the ring 59 and the rate of flow of the compensating liquid through the compensator pump is substantially proportional to the degree of the cocking of the press slide so that the compensating means described are automatically adjusted to effectively oppose and correct any objectionable cocking of the press slide. The described compensating means preferably may be so designed as to correct even slight cocking of the slide and to prevent such cocking from going beyond permissible limits at any time.

Although the compensating pumping action of the pump 51 has been described only as it operates to correct downward movement of the left side of the slide in advance of the right side thereof, it should be clear that if the said right side moves ahead of the left side, an opposite coaction of the screw 70 and the nut 73 occurs, so that the ring 59 is shifted to an eccentric position toward the left of the rotor 55. When the said ring is in the latter position the flow of liquid through said pump is from the liquid supply of chamber 20b to the liquid supply of chamber 20a and thus yields the desired compensation in a manner opposite to that already detailed.

The second embodiment of the invention, illustrated in Figs. 5 and 6, differs from the first embodiment principally in that the racks 63 are arranged so that the teeth on one of said racks face toward the front of the press while the teeth on the other rack face toward the rear of the press whereby said racks, through the step-up gears 66, drive the shafts 65l and 65r in opposite directions rather than in like directions; and in that a differential mechanism 85 is employed between said shafts instead of the described screw and nut arrangement.

The differential mechanism, as best seen in Fig. 6, comprises bevel gears 86l and 86r, keyed respectively upon the inner ends of shafts 65l and 65r and meshing with bevel differential gears 87 which are mounted within a cage 88 upon studs 89. The cage 88 preferably is so mounted within suitable bearings in brackets 69 as to be capable of pivotal movement coaxially of the shafts 65l and 65r. An arm 90, fixed upon or formed integrally with the cage 88, extends upwardly from the latter and to the upper end of this arm is connected a turnbuckle-link 60 which, as in the first embodiment, is connected to and operates the flow regulating mechanism of the compensator pump.

It should be clear that after the differential mechanism is assembled and properly connected

to the compensator pump with the ring 59 of the latter in its concentric or neutral adjustment and the press slide 16 and bed 11 in parallelism, a uniform downward movement of the slide 16 causes the shafts 65*l* and 65*r* to move in similar degrees but in opposite directions, so that the rotation imparted to the differential gears 87 by the bevel gear 86*l*, tending to turn the cage 88 in one direction, is exactly counteracted by the rotation imparted by the bevel gear 86*r* to said differential gears, tending to turn said cage in its opposite direction. It, hence, results that while the slide 16 moves downwardly in parallelism with the bed 11, the cage 88 and the arm 90 remain at rest, leaving the compensator pump in its non-pumping adjustment.

On the other hand, if one end of the slide 16 moves downwardly ahead of the other end thereof, one of the shafts 65*l* and 65*r* turns to a greater degree than the other, thus, through the differential gears 87, imparting a rotative movement to the cage 88 which carries the arm 90 with it to move the ring 59 toward whichever eccentric position will yield the proper pumping action of the compensator pump. It is to be understood, of course, that the compensating action of the said pump is similar in both embodiments described herein.

The location of the compensator pump is not critical and has only been indicated diagrammatically in Fig. 4. It may, if desired, be mounted upon the crown of the press or other fixed supporting structure and any suitable linkage may be employed for connecting the nut and screw mechanism or the differential mechanism to the said pump.

The apparatus illustrated in the accompanying drawings and described in this specification may, of course, be varied in many respects or may be applied to various types of presses without, however, departing from the spirit of the invention as defined in the accompanying claims.

What I claim is:

1. Apparatus for controlling the slide movement in a long-bed hydraulic press having two or more symmetrically-disposed slide-actuating rams and related ram advance chambers, the said apparatus comprising a compensator pump, connected between ram advance chambers at opposite sides of the press slide and having flow regulating means for reversing the direction of flow of liquid through said pump and for controlling the volume of such flow, and pump-adjusting means, controlled by the advance movement of the press slide and adapted to coact with said flow regulating means to so adjust the said pump that the latter operates to transfer liquid, during the advance movement of said slide, in the proper direction and in suitable volume between the said ram advance chambers to effect the advance of the press slide in substantial parallelism with the press bed.

2. Apparatus for controlling the slide movement in a long-bed hydraulic press having two or more symmetrically-disposed slide-actuating rams and related ram advance chambers, the said apparatus comprising a compensator pump, connected between ram advance chambers at opposite sides of the press slide and having flow regulating means for reversing the direction of flow of liquid through said pump and for controlling the volume of such flow, a pair of movable members coacting with the press slide at opposite sides thereof and with said flow regulating means whereby to control the operation of the latter in relation to the parallelism of the advance movement of said slide.

3. Apparatus for controlling the slide movement in a long-bed hydraulic press having two or more symmetrically-disposed slide-actuating rams and related ram advance chambers, the said apparatus comprising a compensator pump, connected between ram advance chambers at opposite sides of the press slide and having flow regulating means for reversing the direction of flow of liquid through said pump and for controlling the volume of such flow, a pair of rotatable shafts, driving means at each of opposite sides of the press slide, controlled by the movement of the latter and adapted to coact with and separately drive said shafts, during the advance movement of said slide, to degrees which correspond or differ in accordance with the parallelism or non-parallelism of the press slide, a pair of coacting members, constrained to rotate separately with the said pair of shafts, and motion transmitting means operatively arranged between said pair of coacting members and the flow regulating means of the said pump, the said motion transmitting means being adapted to coact with the said pair of coacting members to derive movement from rotation of the latter to unlike degrees and to transmit such derived movement to the said flow regulating means whereby to so control the direction and volume of flow of liquid through said pump as to substantially compensate for non-uniform advance movement of the press slide.

4. Apparatus according to claim 3, further characterized in that the driving means for driving the said pair of rotatable shafts comprises, at each side of the press, a rack, and a pinion, fixed upon one of said shafts and adapted to be driven by said rack, the said rack and pinion being carried, one upon the slide of the press and the other upon a fixed part thereof.

5. Apparatus according to claim 3, further characterized in that the driving means for driving the said pair of rotatable shafts comprises, at each side of the press, a rack, carried upon the slide of the press, and a pinion, fixed upon one of said shafts and adapted to be driven by said rack, the said pinion and its related shaft being mounted upon a fixed part of the press.

6. Apparatus according to claim 3, further characterized in that the said pair of coacting members comprises a screw member carried on one of said shafts and a nut member carried on the other of said shafts and having a threaded portion adapted to work upon the threaded portion of said screw member, both said screw member and said nut member being fixed against rotative movement relative to their said related shafts and one only of the two last-mentioned members being slidable longitudinally with respect to its related shaft, whereby any relative rotative movement of the two said shafts operates to slidably move said slidable member to actuate the motion transmitting means and the flow regulating means of said pump.

7. Apparatus according to claim 3, further characterized in that the said motion transmitting means comprises a lever operatively connected between said pair of coacting members and the flow regulating means of the said pump.

8. Apparatus according to claim 3, further characterized in that the said pair of coacting members comprises gears in a differential assembly, and in having a differential cage adapted for rotation in response to differences in the

degrees of rotative movement of said gears, and a lever, adapted for operation in response to rotation of said cage and connected to the flow regulating means of the said pump whereby to control the operation of the latter.

9. Apparatus for controlling the slide movement in a long-bed hydraulic press having two or more symmetrically-disposed slide-actuating rams and related ram advance chambers, the said apparatus comprising a plurality of pumping systems adapted to pump primary supplies of liquid separately to each of said chambers, and means for transferring liquid, during the advance movement of the said slide, from the said primary liquid supply of a ram advance chamber located toward one side of the press to the primary liquid supply of a ram advance chamber located toward the opposite side of the press, to an extent substantially sufficient to compensate for inequalities in the volumes of said primary liquid supplies arising from unequal resistance to the advance of the press slide.

EARL CANNON.