

Nov. 4, 1952

R. C. WILSON
MEANS FOR ADJUSTING FLUID MOTOR ELEMENTS
TO MAINTAIN SYNCHRONIZED MOVEMENT
Filed Aug. 24, 1949

2,616,265

FIG. 1

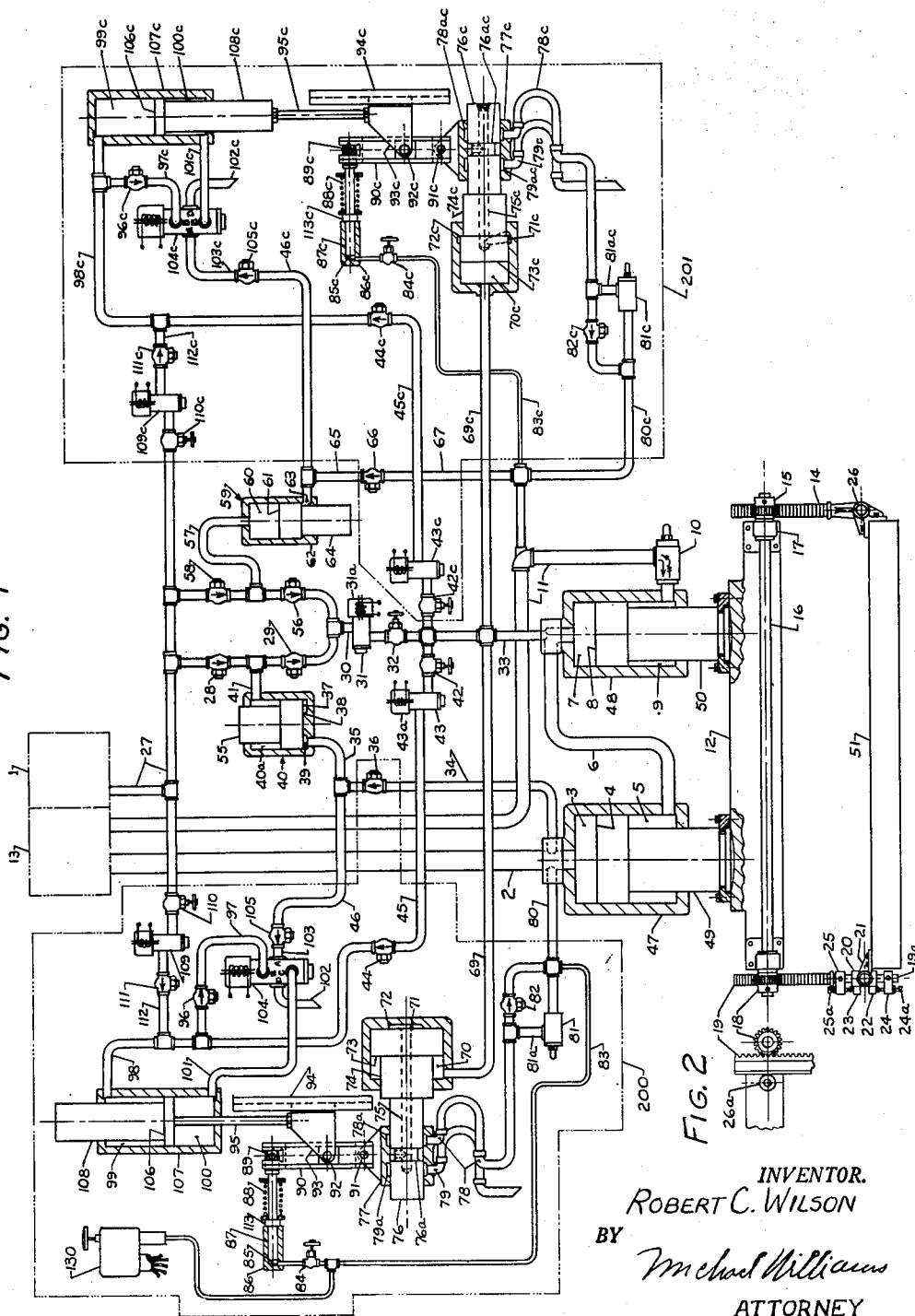


FIG. 2

INVENTOR.
ROBERT C. WILSON
BY *Michael Williams*
ATTORNEY

UNITED STATES PATENT OFFICE

2,616,265

MEANS FOR ADJUSTING FLUID MOTOR ELEMENTS TO MAINTAIN SYNCHRONIZED MOVEMENT

Robert C. Wilson, Warren, Ohio

Application August 24, 1949, Serial No. 112,043

9 Claims. (Cl. 60—97)

1

My invention relates to means for adjusting an element or elements and has for its principal object to provide new and improved means of this character.

The invention has particular application to means for causing to move in unison, or according to some convenient ratio of motions, or aligning the position in accordance with that ratio, two or more hydraulically operated pistons (or cylinders) for the purpose of performing some useful work or function, regardless of the relative amount of axial load within the capacity of the means and which is applied to each at a given instant, and which load is substantially stationary, resists motion of the pistons, or is the means by which motion is produced and against which the pistons, singly or in combination, act as resistance.

Generally, my invention comprises connecting hydraulic pistons in a hydraulic system in series relationship, that is, using the motion of one of the pistons, which, itself, may or may not do other useful work, to move fluid affecting the movement of the other of the pistons, so that the latter piston or pistons move in whatever ratio exists between it (or them) and the first named piston, and further comprises means for compensating the effect of variables by adding or removing fluid from the supply of the latter piston or pistons.

My invention has great application in industry, and for example, but by no means as limitations, my invention may be used in the hydraulic system of a press for advancing or retracting the press platen, and including means for preventing, within practicable close limits, one end of the platen from lagging behind or preceding the other end, to compensate for unequal loading of the platen. My invention may also be used in combination with a system for raising or lowering a long sheet piler table, especially where the length of the sheet or position of the pile on the table varies considerably. Further, my invention may be used to obtain accurate adjustment of motion or position of separate pieces when one of such pieces is caused to move. It will be appreciated that many other applications, not herein specifically mentioned, are possible. In the drawing accompanying this specification, and forming a part of this application, there is shown, for purposes of illustration, an embodiment which my invention may assume, and in this drawing:

Figure 1 is a generally schematic view of a hydraulic system showing an embodiment of my invention, and

Figure 2 is a fragmentary view of a detail of construction shown in Figure 1.

Referring to the drawing, the embodiment

2

herein shown to disclose the invention is applied to a hydraulic system for a downclosing press, although it will be appreciated that such application is for illustration purposes only.

The press herein shown comprises a movable platen 12 and a stationary bed or bolster surface 51, the platen, in this instance, being moved by two pistons 4 and 8 which are connected to the platen in any suitable manner. Fluid under pressure for the purpose of operating the system may be provided from a suitable source 13, such as a fluid pump or fluid supply system.

A conduit 2 leads from the fluid source 13 to the top of the cylinder of the piston 4, and a conduit 11 leads from the fluid source to the bottom of the cylinder of the piston 8, the connections being so constructed and arranged that either conduit may be a supply line or a return line for fluid, depending upon the direction of travel of the platen. A source of auxiliary fluid pressure 1 is available at all times while the fluid source 13 is operating, and this auxiliary supply has a minimum pressure sufficient to be applied to support the platen and articles attached there-
to against the force of gravity.

In advancing the platen 12 toward the bolster surface 51, suitable valve means (not shown) are shifted so that fluid under pressure from the source 13 is delivered through the conduit 2 to the space 3 of the cylinder for the piston 4. The piston 4 is movable in a cylinder to provide an effective diameter D_1 , and fluid pressure against the piston causes it to move downwardly in its cylinder. The piston rod 49 is of smaller diameter, D_2 , than the piston 4, and as this piston moves downwardly the annular space 5 below the piston is decreased in cubic content, thus displacing fluid therein through a conduit 6 to the cylinder for piston 8, to cause this piston to move downwardly. For purposes of this description, the piston 4 will be referred to as the master piston and the piston 8 will be referred to as the servant piston.

In the case (as in the embodiment herein shown) where it is desired that the master and servant pistons move substantially each an identical amount, the cross-sectional area of the annular space 5 is equal to the effective area of the piston 8 having an effective diameter D_3 . Thus, for all practical purposes, and disregarding variables such as fluid compressibility, leakage, elasticity of materials, and the like, downward movement of the piston 4 will effect corresponding and equal movement of the piston 8. Mathematically the diameters relate as follows:
 $D_1^2 - D_2^2 = D_3^2$.

During stationary periods or motion downward, the platen and connected parts are pre-

vented from falling of their ownweight by fluid compressed in the annular space 9 in the cylinder below the piston 8 and by resulting pressure in the annular space 5 in the cylinder below the piston 4. Pressure in the space 9 is maintained by a relief valve section of a counterbalance or foot valve 10. The valve 10 may be of any available commercial construction and accordingly need not be described in detail. Suffice it is to say that the valve 10 permits free fluid flow from the conduit 11 into the annular space 9, but prevents, except by leakage, fluid flow from the annular space 9 and into the conduit 11 until after a predetermined fluid pressure is reached in space 9. The valve is so set as to open at a pressure which is slightly higher than the pressure resulting from the weight of the parts acting upon the effective cross-sectional area of space 9. Thus, to move the platen 12 downwardly even against no platen resistance requires a positive pressure in cylinder space 3 which in turn increases the positive pressure in spaces 5, 7 and 9 sufficient to open valve 10. Accordingly, a partial vacuum which ordinarily would falsify the volume of spaces 5 and 7 and conduit 6 is avoided.

In moving the platen 12 in a direction away from the work and toward its open rest position and, also for compensating for leakage so as to maintain the platen in its rest position, the valve controlling fluid flow through conduits 2 and 11 is shifted so that fluid under pressure is supplied through conduit 11, and the valve 10 provides free passage of such fluid to the annular space 9 below the piston 8. When sufficient pressure is exerted in the space 9, the piston 8 is moved upwardly, moving its corresponding end of the platen. Also, as the piston 8 moves upwardly, the space 7 is decreased in cubic content and fluid is displaced from this space and flows through conduit 6 to the annular space 5 below the piston 4, and as a result the piston 4 is moved upwardly in unison with the piston 8, and that end of the platen to which the piston 4 is connected is also moved upwardly. During this operation, fluid is displaced from space 3 above the piston 4 and flows through conduit 2, which is either connected to pump intake or to a reservoir or drain. Thus, it will be appreciated that the functions of the master piston 4 and servant piston 8 are reversible, depending upon whether the platen is to be lowered or lifted.

The foregoing means and method preferably are used in cooperation with a means to add or remove fluid from space 7 when necessary to maintain the platen parallel to the bolster plate within the desired degree of accuracy. A simple example of such an application might be the foregoing means combined with a manually operated valve to add or remove fluid from space 7 by the skill of the operator observing the effect on the work.

For the purpose of detecting the effect on the angular position of the platen as caused by such variables as leakage, fluid compressibility, elasticity of parts, and the like, my invention provides an indicating means, one embodiment of which will now be described.

Secured to one end of a stationary bed or bolster plate 25, in any suitable manner, as, for example, by a pin passing through a bracket 26, is an accurately cut spur-gear toothrack 16 of a desired length. The rack 14 is in mesh with an accurately cut spur-gear 15, proper rack and gear engagement being held in any suitable man-

ner, such as by a back-up roll. Fixed rotatably with the gear 15 is a suitably rigid shaft 16 which is mounted in spaced bearing brackets 17 carried by the platen 12.

A spur-gear 18, similar to the gear 15, is secured to the opposite end of the shaft for rotation therewith. The gear 18 meshes with a spur-gear rack 19 which is similar to the rack 14. The rack 19, however, has a rod section 19a which has a sliding bearing fit with a bearing block 20 secured to the bolster plate 51 so as to hold the rack 19 to longitudinal reciprocal movement. The top of rack 19 may also move in direction generally parallel to the axis of the shaft 16, since the bearing block 20 has pin engagement with a supporting block 21 secured to the bolster plate 51. A back-up roller 26a engages the rear surface of the rack 19, and maintains it in proper meshing relationship with the gear 18.

Secured to the rod section 19a of the rack 19 is a pair of spaced-apart collars 24 and 25, each of which may be adjusted along the rod section 19a and held in desired adjustment by means of set-screws. The collars 24 and 25 respectively carry adjustable screws 24a and 25a. The bearing block 20 carries a pair of electrical limit switches 22 and 23, each having an operating stem in line with a respective screw 24a, 25a.

Thus, by means of the connected gears 15 and 18, at any given instant, gear teeth on both racks are always at the same position relative to the platen plane even though this plane has been shifted with respect to the bolster plate. As long as the platen 12 moves up and down in a plane initially established by the point of gear mesh and by the position of the adjusting screws 24a, 25a with respect to the limit switches 22, 23, neither limit switch stem will be operated by an adjusting screw.

If, for example, the left hand end (with reference to the drawing) of the platen 12 began to precede the right hand end during advancement of the platen 12, or if the left hand end lags the right hand end while returning, or would tend to drop while at rest, the rack 19 would be lowered a corresponding amount through engagement with the gear 18, and the adjusting screw 25a would be moved into engagement with the operating stem of limit switch 23 to effect operation of this limit switch.

On the other hand, if the right hand end of the platen preceded the left hand end during advancement of the platen, or if it lagged during retraction or tended to fall, the rack 19 would be moved upwardly to bring adjusting screw 24a into operating engagement with the stem of limit switch 22.

It will be appreciated that instead of limit switches 22, 23, suitable valves or mechanical indicators may be used for cooperation with the respective adjusting screws 24a, 25a. Operation of the limit switches (or valves and the like) may actuate a correction means as later described or a signalling device to indicate to an operator that the platen 12 is not running according to a desired angular relation with respect to the bolster plate 51, so that the operator may make necessary adjustments, either mechanically or hydraulically.

In the present embodiment, the limit switches provide for automatic compensation when the platen is not running in desired angular relation with respect to the bolster plate, and for this purpose when the left side of the platen is lower

than the right side, the limit switch 23, operated by this condition, is electrically connected to energize the solenoid 31a of a normally closed solenoid-operated spring-returned two-way valve 31 and so permit flow of fluid under pressure through conduit 30 and 33 to the cylinder of servant piston 8. When the right side of the platen is lower than the left side, limit switch 22 operated by this condition is electrically connected to energize the solenoid 43a of normally closed solenoid-operated spring-returned two-way valve 43 and so permit flow of fluid from the cylinder of servant piston 8 through conduits 33 and 45. The conduit 45 for the present time may be considered a drain conduit. A needle valve 42 or other means for controlling flow is preferably interposed in conduit 33 leading to solenoid valve 43, and a similar needle valve 32 or flow control valve is preferably interposed in conduit 30 leading from solenoid valve 31. For the present it is convenient to assume that the check valve 44, solenoid valve 43c, needle valve 42c, check valve 44c, and conduit 45c are non-existent.

For purposes of the description of the means and methods up to this point, it may be assumed that conduit 30 is connected to a source of fluid under a pressure higher than that in space 7 of the cylinder of servant piston 8, so that if the platen is rotated to effect operating of limit switch 23, the solenoid valve 31 will be opened to permit fluid to pass through conduits 30, 33 to the space 7 above the servant piston 8, and this servant piston will be urged downwardly a sufficiently greater amount than the master piston 4, or the master piston will be urged upwardly as the case may be, so that the platen 12 will be re-aligned. As soon as the platen is re-aligned the operating stem of limit switch 23 will be disengaged from adjusting screw 25a and the valve 31 closed. In the event the platen 12 is oppositely rotated sufficiently to operate the limit switch 22, the valve 43 will be opened so that pressure fluid from the space 7 above the servant piston 8 may flow through conduit 33 to drain, or to be used by other mechanism, whereby fluid volume in the space 7 will be reduced sufficiently to allow either the servant piston 8 to move upwardly or the master piston 4 to move downwardly a sufficient amount to re-align platen 12, and, thus, to stop flow by releasing stem of limit switch 22 which closes valve 43. By means of multiple limit switches operated successively, or a rheostat or the like in combination with multiple valves, or a variable orifice valve, fine and coarse rates of fluid addition or removal may be had. That is to say, if only slight misalignment occurs only a small amount of fluid would be necessary for a fine correction, whereas if large misalignment occurred then a correspondingly large amount of fluid would be necessary for coarse correction.

For general applications and especially where the loading on the platen changes to some unpredictable position at substantially every stroke, the foregoing described methods and means would suffice.

In the present embodiment, the higher-pressure fluid for conduit 30 is provided by a pressure intensifier 40. As herein shown, the annular space 40a of the intensifier cylinder 38 is connected by conduit 41 to conduit 30 through a check valve 29. The intensifier 40 is charged when not in use from an auxiliary pressure line 27, the pressure of which is sufficient to be used by valve 31 in maintaining the rest position of

the platen and its connected parts against gravity. Check valves 28 and 56 prevent the escape of fluid under pressure developed in space 40a to regions which at the time may be of lower pressure.

The intensifier 40 includes a piston 37 working in a cylinder 38, the reduced-diameter rod end 55 of which cooperates with the cylinder 38 to form the annular space 40a. A conduit 35 leads from the piston-face end of the cylinder and a check valve 36 is interposed in this line, but for the present it is convenient to consider valve 36 as being non-existent. A conduit 34 establishes communication between the check valve 36 and the pressure supply conduit 2. As fluid pressure increases in the conduit 2, such pressure is also applied to the face of the piston 37 to urge such piston upwardly (with respect to disposition of parts in the drawing) so as to tend to reduce the volume of the space 40a and thus build up a higher pressure therein than that supplied by the input fluid because of the unequal areas existing on opposite sides of the piston 37. As before described, the high pressure built up in the chamber 40a will be used to re-align the master and servant pistons if and when valve 31 is opened by limit switch 23. Any fluid exhausted from annular space 40a is replenished during the return stroke of the platen, since at that time no pressure exists in conduit 2, and fluid under pressure from the auxiliary source may flow through conduit 27, past check valve 28 and to annular space 40a, and such pressure acts against piston 37 and forces it downwardly against the head of cylinder 38.

Although any other suitable source of fluid under pressure may be used to operate piston 37, fluid pressure from conduit 2 is preferable, since in operating piston 37, which for a given input pressure is constructed to produce a higher pressure output than the output of the master cylinder some or all fluid is denied piston 4, and as a result piston 4 hesitates or is slowed in its movement until piston 8 is brought abreast.

During the time the platen is returning, that is, during its upward travel, against resistance, and when fluid under pressure needs to be added to spaces 5 and 7 in order to re-align the platen, addition of fluid through conduit 30 originates in space 60 through conduit 57 which at that time is maintained at higher pressure than the pressure in space 7 by means of a deintensifier 59, which, in certain cases could be replaced by direct connection of conduit 57 to conduit 11.

The de-intensifier 59 and connected means are used principally to operate apparatus to be described subsequently but are also used to increase the amount of fluid originating in conduit 11 to be added to space 7 when required by valve 31, so that returning motion of the platen will proceed more smoothly. In other words, because of the relatively small cross-sectional area of the annular space 9 of the servant cylinder, a small amount of fluid supplied to such space produces a comparatively large amount of movement, and likewise, if a small amount of fluid were removed from conduit 11 and added directly to space 7 in order to make minor correction to the angular position of the platen, while correction was being made the platen might stop entirely for an objectionable length of time during its return motion.

The pressure de-intensifier 59 is charged during or before the platen 12 is in the advancing half of its stroke, so that at this time fluid flows

from the auxiliary pressure conduit 27, through check valve 58 and through conduit 57 to the space 60, so as to drive the piston 61 downwardly against the rod end of cylinder 62. Fluid below the piston 61 is exhausted from the cylinder 62 by means of a conduit 65, which for the present time may be considered as connected to drain.

To move the piston 61 upwardly from the rod end of the cylinder 62, fluid under pressure from conduit 11 is utilized. For this purpose, a branch conduit 67 is connected to conduit 11, a check valve 66 being interposed between the connection of conduits 67 and 65, for the purpose of permitting fluid flow to the rod end of cylinder 62 but preventing such fluid from returning to the conduits 67 and 11. The check valve 66, like check valve 36, is not required for odd job presses, and could for these applications be eliminated so that conduit 65 connects directly to conduit 11.

The pressure of fluid in annular space 63 acts on the rod side of piston 61, applying a force thereto which produces sufficient motion of the piston so as to displace fluid from space 60 in volume greater than the volume of fluid delivered to space 63. In general, the ratio of areas of space 63 compared with space 60 is such as to provide a hydraulic advantage over the ratio of areas of space 9 compared with space 7. It will be appreciated that any other source of higher pressure fluid, such as that in conduit 11, may be utilized in place of the pressure intensifier 59.

The foregoing description, in summary, discloses means and methods for causing the platen to remain parallel to the bed until some variable factor or factors cause the platen to rotate either while stationary or while moving, and then after rotative misalignment occurs, which is detected by the indicating means comprising the limit switches 22, 23, to correct such misalignment by adding or removing fluid as required.

The means and method about to be described cooperates with the foregoing means and methods but serves the additional purpose of anticipating the degree of correction of the platen which will be required as variables occur and of making correction on this basis during occurrence of variables, which, if left uncorrected, would ordinarily produce misalignment of the platen with respect to the bolster plate.

The means illustrated in the drawing, and the means and method herein described, at the present time are considered preferable, although it will be appreciated that the invention is not limited to this specific disclosure. A simpler means than is later described, for example, follows. Experimentally, the average amount of fluid which must be added to make up for compressibility, fluid leakage, elasticity of parts, and the like, is found for increments of the stroke of the platen and a curve "amount of addition vs. stroke" is plotted. A suitable plunger pump for making addition and later for removing this addition, may be constructed and operated by a cam which satisfies the conditions of the above curve and which, in turn, is moved directly or indirectly by the motion of the platen. In this case the degree of correction is proportional to the effective area of the pump, whereas the rate of correction is determined by the slope of the cam.

The means and methods herein disclosed, however, use the present and/or previous amounts of additions and/or removals of fluid to determine

the degree of correction required and the pressure fluctuation of the primary supply of fluid to determine the rate at which correction is applied.

In the embodiment of the invention herein disclosed, apparatus to the left of the conduit 2, that is, the apparatus within the dot-dash line 200 relates to means and method of determining and making the degree and rate of correction while the platen is advancing and the apparatus at the right hand side of the drawing, that is the apparatus within the dot-dash line 201 relates to means and method of determining and making the degree and rate of correction while the platen is returning.

Referring to the drawing, fluid is added to spaces 5 and 7 and subsequently removed again by contraction and subsequent expansion of the length of the annular space 70 formed by a cylinder 72 and the piston rod 74 of a piston 73. The operating face of the piston 73 is normally held against the head of the cylinder 72, as will be explained. The piston 73 is moved away from the cylinder head by means of fluid supplied to an undercut 71 in the head of the cylinder 72. Fluid reaches undercut 71 through a passage 75 extending through the piston 73 and piston rod 74, and partially through a valve spool 76 connected to or integral with the piston rod 74.

The valve spool 76 has an annular groove 76a which communicates with the passage 75. The bore of valve body 77 mates with the valve spool with a sliding fit, and, when this body is caused to slide in a direction away from the piston rod 74, the internal, annular, cored passage 78a of the valve body passes partially over the adjacent lip of the groove 76a and permits fluid to flow from a flexible conduit 78 to groove 76a and through passage 75 to undercut 71, such fluid acting on the operating face of the piston 73 to drive such piston in the same direction as that in which the valve body 77 was moved. Movement of the piston will continue until the groove 76a is again sealed from the passage 78a.

On return movement of the valve body 77, if the piston 73 is not already against the head of cylinder 72, the internal cored passage 78a of valve body 77 passes partially over the adjacent lip of the groove 76a and permits fluid from passage 75 to enter the annular cored passage 79a and to pass through a flexible conduit 79 to drain, thus removing fluid from undercut 71 and permitting the piston 73 to move by means of pressure in space 70, which pressure originates in space 7, toward the head of the cylinder 72 and in the same direction as the valve body 77 was moved. Motion of the piston 73 will continue until the piston hits the head of the cylinder 72 or until the groove 76a has moved sufficiently to seal cored passage 79a. This arrangement is one form of a servo valve control, and permits a light force, generally sufficient to overcome sliding friction, applied to the valve body 77 to control the motion and position of piston 73, which in turn controls the volume of space 70. It will be appreciated that my invention is not limited to the particular form or arrangement of parts as specifically shown.

Fluid for operating the piston 73 is supplied through conduit 78, as just described, and this conduit is connected to a conduit 80 leading into conduit 2. A check valve 82 is interposed in the line established by conduits 78, 80, and this check valve permits free flow of fluid from the conduit 78 to the conduit 2, but prevents flow of

fluid in the reverse direction. A branch conduit 81a by-passes the check-valve 82 and a low pressure relief valve 81 is interposed in this branch conduit whereby fluid may flow under slight differential pressure from the conduit 2 to the conduit 78. The relief valve 81 provides for control of minor pressure fluctuations so that the piston 73 is not shifted undesirably. The check valve, in permitting flow from conduit 78 to conduit 2 provides for rapid de-compression of the fluid in space 70. In certain instances, valves 81 and 82 may be eliminated and conduit 78 may be connected directly to conduit 2.

Since it is desirable that fluid addition from space 70 of cylinder 72 to space 7 of the servant cylinder should take precedence over addition of fluid from space 40a of intensifier 40 to space 7, even though valve 31 is open at that time, hydraulic advantage is provided for space 70 by making input output ratio of the cylinder 72 slightly higher than input output ratio of the intensifier 40. Thus, during advancing movement of the platen 12, when variables are encountered which would tend to produce platen rotation, the means for making simultaneous correction takes precedence over the means for making correction after rotation has occurred, and this, of course, takes precedence over means which causes further motion of the platen, until correction is made.

The valve body 77 is connected to one end of a lever 90 by means of a pin 91 which both mounts the lever and permits it to rotate in the plane of the drawing. The other end of the lever is attached, by means of rod-eye and block connection 89, to a suitable small piston 87, the axis of which is substantially parallel to the axis of the valve spool 76. The piston 87 operates within a stationary cylinder 86 and is moved outwardly from this cylinder when fluid under pressure is supplied to the space 85 within the cylinder. Fluid under pressure is supplied to the cylinder by means of a conduit 83 which is connected to the conduit 80 and thus receives fluid from the conduit 2. A needle valve 84 is interposed in the conduit 83 to control flow of fluid therethrough.

The piston 87 is normally bottomed in the cylinder 86 so that a stop collar 113 is held against the cylinder face by a light force produced by a spring 88. The opposite end of the spring 88 seats against a stationary washer, and the spring opposes motion of the piston to a certain degree. The spring 88 has suitable loading deflection characteristics so as to hold the piston 87 to accurate movement in linear proportion to the fluid pressure in space 85.

When the system is at rest, that is, when stop collar 113 is against the face of cylinder 86; when piston 73 is against the head of cylinder 72; and when the core passages 78a and 79a in servo valve body 77 are in neutral or sealed-off position, then the position of parts is such that a line which is established as the lever center-line by joining the center of pin 91 with the center of the pivot in sliding block 89 is substantially at right angles with the longitudinal axis of the valve spool 76.

A carriage 93 is slidably mounted in ways on a stationary base 94, in position to slide substantially parallel with the "at rest" position of the center-line of the lever 90. The carriage has supports for trunnion pins 92 on both sides of the lever which pins are integral with blocks slidably in machined ways in each side of the

lever. By moving the carriage 93 along the base 94, the center of rotation formed by the trunnion pins 92 may be made to coincide with the rotating center of the servo-valve connecting pin 91 or the rotating center of the rod eye 89, or any intermediate point therebetween. The trunnion pins and blocks provide a movable fulcrum for the lever 90.

The movable fulcrum provided by the pins 92 and the lever 90 provides a means for varying the movement of the servo-valve body 77 with respect to the movement of the piston 87, the latter moving in linear relation to the fluctuation of pressure in conduit 2. The movement of the servo-valve body 77, however, controls the amount of fluid which is produced by or returned to space 70 and thus controls the amount of fluid added to or removed from space 7 of the servant cylinder, and therefore effects a means for correcting platen rotation. Taking pressure rise from zero to a given pressure in conduit 2, less fluid will be added to space 7 of the servant cylinder if the fulcrum center of lever 90 is closer to pin 91 than if it were closer to eye 89, and vice versa.

If the amount of fluid which was added to space 7 of the servant cylinder by valve 31 during the advance portion of several previous platen strokes is used, through suitable means, to move the fulcrum of lever 90 toward eye 89, then the amount of fluid added from space 70 to space 7 will be increased for following strokes as the pressure rises in conduit 2, and will successively diminish the amount which must be added by valve 31 as the result of that rise in pressure if the factors which tend to produce platen rotation remain fairly constant for the set of platen strokes under consideration.

If, to the contrary, the amount of fluid removed from space 7 of the servant cylinder during the advance portion of several previous platen strokes is used, through suitable means, to move the fulcrum of lever 90 toward pin 91, then the amount of fluid added from space 70 to space 7 will be decreased for following strokes as the pressure rises in conduit 2, and will successively diminish the amount which must be removed by valve 43 as the result of that rise of pressure, if the factors which tend to produce platen rotation remain fairly constant for the set of platen strokes under consideration.

If the two functions, increasing and decreasing of fluid addition, are alternately opposed, that is, if the fulcrum of lever 90 is moved toward pin 91 while the platen is advancing and if the fulcrum of lever 90 is moved toward eye 89 while the platen is returning or at rest, and, further, if conditions which determine the need for correction by fluid from space 70 are constant for the set of platen strokes under consideration, then it follows that the fulcrum of lever will approach and oscillate with decreasing amplitude about an optimum position on the lever which would produce addition of fluid from space 70 of the exact amount of fluid necessary to compensate for variables such as fluid compressibility, pipe line expansion and the like as the pressure in conduit 2 rises.

The foregoing described means and method can be made to operate with considerable accuracy to provide (for a given position of the fulcrum of lever 90) equal increments of correction for equal increments of pressure rise of the system supply, and the foregoing should suffice for most applications. However, where it is desired to be more accurate, experiments may have to be made

to determine for a given fulcrum position what actual increment of correction is required for each successive increment of pressure rise in the supply. Having determined the relation curve "correction vs. pressure," the motion of the eye 89 may then be operated indirectly by the motion of piston 87 through a cam mechanism satisfying the relations found, instead of in the direct manner illustrated.

Loss of fluid in any passage or conduit directly connected to space 7 of the servant cylinder will be the principal reason for causing the fulcrum of lever 90 to oscillate, if all other conditions remain substantially constant. Since the amount of fluid existing in spaces 5 and 7 is constant, and since addition to increase the volume of that in space 7 is made at the expense of a decrease in volume of space 70, which decrease is constant for a given pressure increment and a given fulcrum position, it follows that if leakage depletes the supply, the proper degree of correction will not result from the same amount of volume decrease in space 70 as was formerly sufficient, resulting, consecutively, in slight rotation of the platen, correction by addition through valve 31, and finally movement of the fulcrum toward eye 89.

The next stroke after such correction for leakage occurs will result in too much of a decrease in volume of space 70 because of the new position of the fulcrum at that time which will result in platen misalignment in the opposite direction, correction by removal of fluid through valve 43, and finally movement of the fulcrum of lever 90 toward pin 91. If leakage is slow, the functions described will cause the fulcrum of lever 90 to again reach its original position after a few strokes.

For the average large quantity lot of work done by a press, it may be assumed that during the batch of work while dies remain in the same position, the character of the work is such that the center of work resistance to platen motion will occur within close limits at the same place and remain at its place throughout the stroke. The character of work, however, may be such that the center of work resistance may move radically during each stroke, but in the same manner repeatedly for successive strokes. A good example of this type of work is that of drawing, by means of a punch attached to the platen and a die attached to the bed, a large symmetrically shaped part thus establishing the center of work resistance at the center of the punch, and then, after drawing, embossing heavily one small section located considerably off-center, thus causing the center of work resistance to move rapidly toward the section being embossed. To prevent constant fulcrum oscillation of a large amplitude which would result from such conditions, the preferred method would be to provide means to temporarily block conduit 83 from conduit 2, and instead connect conduit 83 to some different source of suitable regulatory pressure at the time work resistance shifted, and thus artificially produce the desired results.

For purposes of moving the carriage 93, in the embodiment herein shown, a piston 106 is connected to the carriage by a rod 95. When fluid under relatively low pressure is supplied to the space 100 formed by cylinder 107 and piston 106, the piston is driven upwardly (with respect to disposition of parts in the drawing) so as to move the carriage 93 and fulcrum of lever 90 toward the eye 89. During such movement, the an-

nular space 99 behind the piston is decreased in volume, thus displacing fluid therein. When fluid under relatively low pressure is supplied to space 99, the piston 106 is driven downwardly, moving the carriage 93 and fulcrum of lever 90 toward pin 91, and fluid is displaced from space 100.

Fluid supplied to space 99 during normal operation is that which is removed from space 7 of servant cylinder by valve 43 during the advance portion of the platen stroke, and such fluid flows through conduits 45 and 98. Fluid supplied to space 100 is preferably that fluid which is displaced from space 39 of intensifier 40. It has been found convenient to use this displaced fluid both because it is proportional to the amount of fluid added to space 7 by valve 31 and also because it is available for such use during the return portion of platen stroke when space 40a is being recharged. It alternates in this manner with fluid supplied through valve 43. Thus, conduit 46 leads from conduit 35 and connects with conduit 101 leading to space 100. Space 100 is preferably connected to drain when fluid is added to space 99, and conversely, when fluid is added to space 100, space 99 is preferably connected to drain.

Connection of spaces 99 and 100 to fluid source and to drain at the proper time is preferably accomplished by means of a solenoid operated (direct or by pilot valve) spring returned, closed center cross-over, four way valve 104 of any suitable commercially available design. A check valve 105 permits free flow of fluid toward port #A of valve 104 through conduit 103 but prevents outward reverse flow, the inlet side of check valve 105 being connected, by conduit 46 to conduit 35 leading from the intensifier 40. A check valve 96, connected to port #B of valve 104 provides free flow of fluid toward port #B through conduit 97 but prevents flow in the reverse direction.

Space 99 is connected to the entering side of check valve 96 by means of a conduit 98 and this conduit is also connected to conduit 45 leading from check valve 44. Space 100 is connected directly to four-way valve port #C by means of conduit 101. The drain port #D is connected directly to drain or to a fluid storage tank (not shown) by means of conduit 102.

When the platen is advancing (by reason of pressure in conduit 2) the solenoid of valve 104 is energized by means of a pressure switch 130 which is actuated by pressure in conduit 2. When the spool of valve 104 is moved by its energized solenoid, port #A is connected to port #B while port #C is connected to the drain port #D. Fluid pressure in conduit 2, which is also present in conduit 46, is prevented from escaping at that time to conduit 45 by check valve 96. Fluid displaced from space 100 of cylinder 107 is thus drained through conduit 101, and ports #C and #D, when fluid is supplied to space 99 by valve 43 through conduits 45 and 98.

When the platen is returning (by reason of pressure in conduit 11) the solenoid of valve 104 is de-energized, since no pressure now exists in conduit 2 and the pressure switch 130 is spring-pressed to open position, thus permitting the spool of this valve to be spring returned so as to join port #A to port #C and port #B with drain port #D. Fluid displaced from space 39 of intensifier 40, resulting from recharging of intensifier, is supplied to space 100 of cylinder 107 through conduit 46, check valve 105, ports

#A and #C, and conduit 101. Fluid from conduit 46 is prevented from passage to conduit 2 by check valve 36. As the piston 106 is driven upwardly, fluid is displaced from space 99 and passes to drain through conduit 98, check valve 96, conduit 97, ports #B and #D, and conduit 102.

It is desirable that the increment of movement of piston 106 in one direction, as the result of an increment of volume of fluid removed from space 7 of servant cylinder by valve 43, will equal the increment of piston motion in the other direction, as the result of an equal volume increment of fluid but added to space 7 by valve 31. By this is meant that if the cross-sectional area of space 99 were equal to that of space 100, and further if space 100 were supplied with a quantity of fluid exactly duplicating that supplied through valve 31, then a given amount of fluid from one source would produce a given amount of piston motion in one direction, whereas an equal amount of piston motion in the opposite direction would result from the same amount of fluid from another source. Since, however, the amount of fluid available for use in space 100 is larger than the actual amount passing through valve 31 by the proportion of the cross-sectional area of space 39 divided by that of space 40a, then to compensate for this, the cross-sectional area of space 100 should be larger by the same proportion than that of space 99.

The maximum capacity of space 99 preferably should be several times that of fluid which is anticipated to be the maximum to be supplied to space 99 during any one stroke of the platen, and conversely, the same holds true with respect to space 100. This is largely to prevent large amplitude oscillation of the fulcrum with a resulting wide variation in the amount of correction fluid added from one stroke to the next by means of space 70 of servo-controlled intensifier 72.

When for any reason, such as changing the type of work done by the platen, it is desired that no correction on the next stroke (or reduced correction) be made, the solenoid of normally closed two-way valve 109 may be energized only when no pressure exists in conduit 2, and thus supply space 99 with fluid from the auxiliary pressure source through passage 27, flow-control needle valve 110, two-way valve 109 (check valve 111 preventing accidental reverse flow) and passages 112 and 98. Fluid supplied at this time is prevented from escaping to space 39, by means of check valve 105, and also from accidentally supplying space 7 of servant cylinder by means of check valve 44. Supplying fluid under pressure in this manner to space 99, while exhausting fluid from space 100 through valve 104, causes carriage 93 and fulcrum 92 to move toward pin 91, thus decreasing the next stroke of piston 73 and, as a result, decreasing the amount of fluid added to space 7 through passage 70 during the next pressure rise in conduit 2.

If it is desired to eliminate all correction by space 70 during the next platen advance stroke, then solenoid of valve 109 is de-energized by means of a limit switch (not shown) which is tripped by a dog attached to carriage 93 when the center of fulcrum 92 approximately coincides with the center of the pin 91. When this coincidence of centers occurs, provision should be made to allow additional carriage movement in the same direction of an order sufficient to handle the normal anticipated discharge from valve 43 to space 99 during the next stroke. Positioning

the fulcrum 92 of lever 90 coincident with the center of pin 91 does not permanently decommit the function of space 70, but instead allows the necessary degree of correction to be developed in the regular manner.

All that has been described so far is apparatus which would be necessary to obtain the desired degree of accuracy to an application to, for example, a press having the anticipated use of producing large quantities of the average class of work, using dies which customarily remain fixed in one position in the die space and which process of performing work presents forces resisting the returning motion of the platen (die stripping forces for example) which are fairly small in comparison to the forces resisting the advancing motion of the platen. By this is meant that a large fluctuation of pressure does not occur in space 5 of the master cylinder during the time the platen returns, and therefore, no major correction will be needed during return and thus there exists no real need to make correction on the basis of anticipation, since correction of valves 31 and 43c would suffice. The embodiment may be altered, if correction by anticipation were desirable only during the advance portion of the stroke, to the extent that apparatus to the right of conduit 67, that is that apparatus enclosed in dotted lines 201, and conduit 114, would not be required, and conduit 65 would connect directly to conduit 11, making check valve 66 non-essential, and valve 43c, 42c, and 44c together with conduit 45c would be non-existent.

If conditions were such, however, that a large pressure fluctuation, which could be anticipated as repetitive from one stroke to the next, occurs in space 5 during the return portion of the platen stroke, then apparatus shown within the dotted lines 201 would be required. Such apparatus is similar to apparatus within the dotted lines 200, and similar reference numerals with suffix "c" added, designate similar parts. The main material difference is that all functions of the apparatus within dotted lines 201 bear the same relation to the existence of pressure in the conduit 11 as all functions of the apparatus within dotted lines 200 relate to pressure in the conduit 2. Construction of parts is substantially similar, with the exception of reversal of piston and rod relations. To supply the apparatus within dotted lines 201 an additional valve 43c for removing fluid is necessary and is the counterpart of valve 43. By some suitable means, such as by a separate set for contacts operated by pressure switch 130, valve 43 solenoid is only energized by limit switch 22 when pressure exists in conduit 2, whereas valve 43c is energized only when no pressure exists in conduit 2.

From the foregoing, it will be apparent to those skilled in the art that I have accomplished at least the principal object of my invention, and it also will be apparent to those skilled in the art that the embodiment herein described may be variously changed and modified, without departing from the spirit of the invention, and that the invention is capable of uses and has advantages not herein specifically described; hence it will be appreciated that the herein disclosed embodiment is illustrative only, and that my invention is not limited thereto.

I claim:

1. In a system for maintaining movable platen means in substantially true angular relation with

respect to a relatively fixed work surface, a plurality of hydraulically actuated means connected at spaced points to said platen means for moving the same, a supply line for supplying liquid under pressure to at least one of said hydraulically actuated means, said hydraulic actuated means being connected in a hydraulic circuit so that movement of one causes movement of another, pressure intensifier means operated by pressure in said liquid supply line to produce a pressure higher than that in said supply line, and means for selectively introducing said higher pressure liquid into said hydraulic circuit.

2. In a system for maintaining movable platen means in substantially true angular relative with respect to a relatively fixed working surface, a master hydraulically actuated device and at least one servant hydraulically operated device, said devices being connected to said platen means at spaced points for moving the same, and the exhaust of said master device being hydraulically connected to the inlet of the servant device so that movement of one causes movement of the other, a supply line for supplying liquid under pressure to the inlet of said master device, pressure intensifier means operated by pressure in said liquid supply line to produce a pressure higher than that in said supply line, conduit means connecting said intensifier outlet to the both exhaust of said master device and inlet of said servant device, and control means controlling flow of higher pressure liquid through said conduit means, whereby when said control means is actuated certain fluid from said supply line is denied the inlet to said master device to operate said intensifier means and said higher pressure is delivered to both the exhaust of said master device and the inlet of said servant device.

3. In a system for maintaining movable platen means in substantially true angular relation with respect to a relatively fixed working surface, a plurality of hydraulically actuated means connected at spaced points to said platen means for moving the same, said hydraulically operated means being connected in hydraulic circuit so that movement of one causes movement of another, pressure intensifier means operable to increase pressure in said hydraulic circuit to correct undesirable rotation of said platen means during the down-stroke of said platen means, and pressure de-intensifier means to reduce pressure in said hydraulic circuit to correct undesirable rotation of said platen means during return-stroke of said platen means.

4. In a system for maintaining predetermined alignment of relatively movable elements, a plurality of fluid actuated means adapted to effect relative movement of said elements, and means controlled by fluid displacement and operable prior to misalignment of said elements and constructed and arranged to anticipate the amount of correction required and accordingly alter operation of said fluid actuated means in anticipation of such correction.

5. In a system for maintaining predetermined alignment of movable platen means with respect to a fixed work surface, a plurality of fluid actuated means connected to said platen means at spaced points for moving the same, said fluid actuated means being connected in fluid circuit, and anticipating means controlled by fluid displacement and operable prior to misalignment of said platen means and constructed and arranged to anticipate the amount of correction

required and accordingly alter operation of said fluid actuated means, said anticipating means having a portion operable during advancing motion of said platen means and a portion operable during return motion of said platen means.

6. In a system for maintaining predetermined alignment of relatively movable elements, a plurality of fluid actuated means adapted to effect relative movement of said elements, means for ascertaining alignment of said elements, and pressure intensifier and de-intensifier means selectively controlled by said ascertaining means to effect desired relative movement of said fluid actuated means.

7. In a system for simultaneously moving two or more hydraulically actuated means in predetermined relation, correction means operable when said hydraulically actuated means are out of predetermined relation to affect operation thereof to restore said hydraulically actuated means to predetermined relation, and anticipation means responsive to prior corrections resulting from operation of said correction means and operable in accordance therewith to affect operation of the system before said hydraulically actuated means move out of predetermined relation.

8. In a system for simultaneously moving two or more hydraulically actuated means in predetermined relation, a hydraulic circuit connecting said hydraulically actuated means in series relation so that movement of one causes movement of the other, correction means operable when said hydraulically actuated means are out of predetermined relation to continuously modify the volume of fluid in said hydraulic connecting circuit during the time said hydraulically actuated means are out of predetermined relation, and anticipation means responsive to prior corrections resulting from operation of said correction means and operable in accordance therewith to modify the volume of fluid in said hydraulic connecting circuit before said hydraulically actuated means move out of predetermined relation.

9. In a system for simultaneously moving two or more hydraulically actuated means in predetermined relation, a hydraulic circuit connecting said hydraulically actuated means in relation so that movement of one causes movement of the other, detection means affected by movement of said hydraulically actuated means from predetermined relation, and means under control of said detection means and operable to restore the predetermined relation of said hydraulically actuated means by applying a single correction to the volume of said hydraulic connecting circuit, the amount of said correction being determined by the duration thereof.

ROBERT C. WILSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,944,351	Landry	Jan. 23, 1934
2,312,213	Ferris	Feb. 23, 1943
2,328,258	Cannon	Aug. 31, 1943
2,353,388	Cannon	July 11, 1944
2,353,389	Cannon	July 11, 1944
2,400,685	Collins	May 21, 1946
2,462,580	Watson	Feb. 22, 1949
2,487,402	Watson	Nov. 8, 1949