Oct. 23, 1962 F. E. MUNSCHAUER, JR., ETAL 3,059,431

HYDRAULIC POWER TRANSMISSION SYSTEMS FOR PRESS BRAKES AND LIKE MACHINES

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FIG. 1.

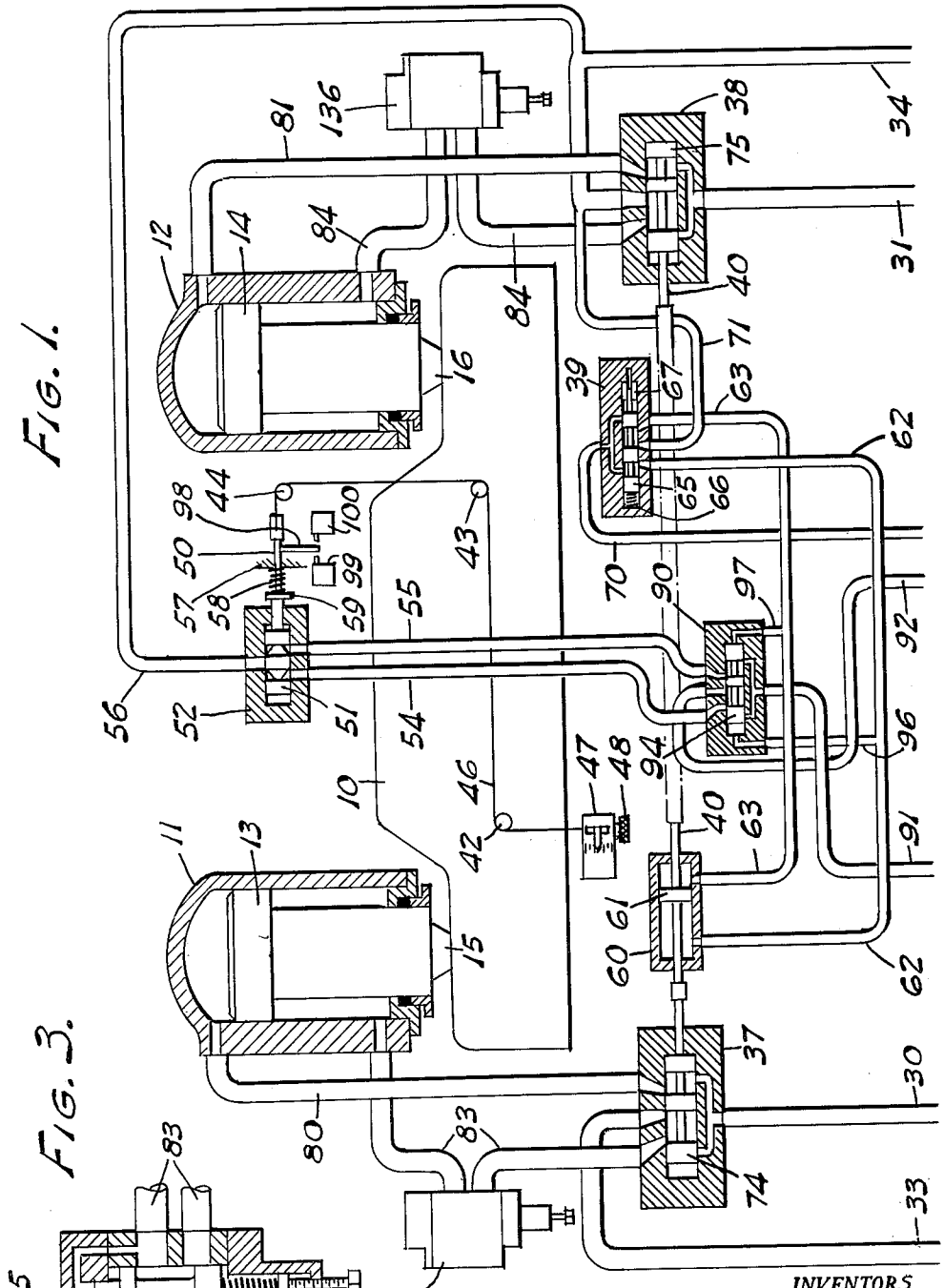


FIG. 3.

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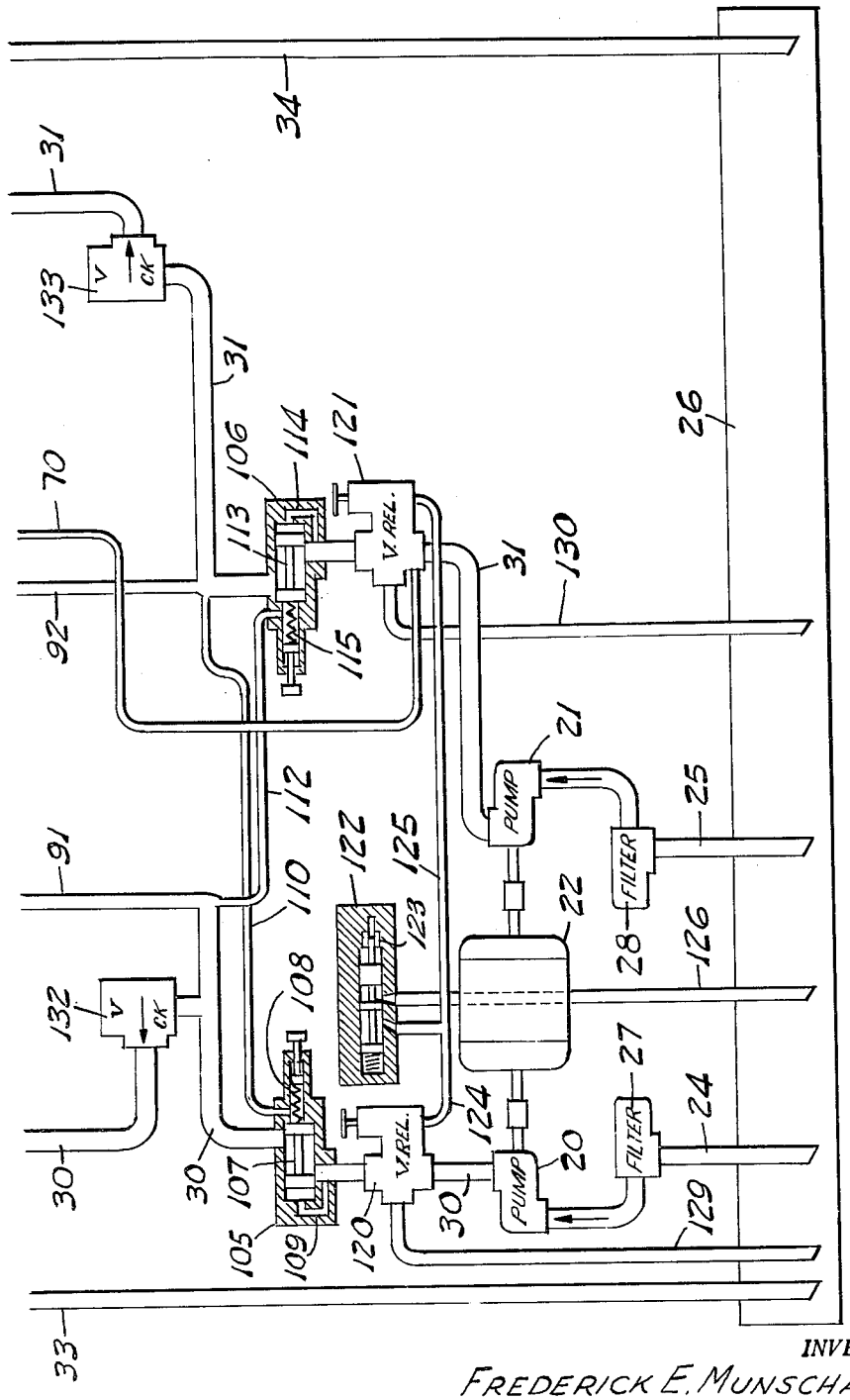


FIG. 2.

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HYDRAULIC POWER TRANSMISSION SYSTEMS FOR PRESS BRAKES AND LIKE MACHINES

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This invention relates to press brakes and similar cyclic metal forming presses or other reciprocating machines and more particularly to presses and the like wherein the ram or movable platen is reciprocated by hydraulic motor means.

In hydraulic press brakes and other hydraulic presses wherein the area or width of the working surface of the press is of substantial extent, it is desirable and common to employ a pair of laterally spaced hydraulic piston and cylinder devices or other hydraulically energized actuators for reciprocating the ram or movable platen by hydraulic motor forces applied at such spaced points, as for instance adjacent to the opposite ends of the ram in a press brake.

This general drive arrangement presents a problem in synchronizing the vertical movements of the opposite ends or sides of such a ram or movable platen or, stated another way, necessitates special arrangements or provisions for maintaining an accurately level attitude of the ram or movable platen during its descent and ascent. This problem is aggravated by the natural tendency of a ram or platen to go out of level under eccentric loading, the side of the ram or platen having the lesser load naturally tending to descend ahead of the heavier loaded side.

Various efforts have been made in the prior art to provide automatic levelling means for hydraulic press brakes and analogous hydraulically reciprocating machines. The present invention provides an improved hydraulic machine of this class wherein a pair of hydraulic motors are automatically controlled by the attitude of the ram or platen of the machine so that any tendency to move out of level is immediately and precisely corrected to return the ram or platen to level condition. More particularly, the hydraulic system of the present invention is such that the leveling function is accomplished in a highly precise manner and in such a way that the ram or platen is directly restored to level condition without hunting or overcorrection.

In arrangements proposed for this general purpose in the prior art the correction system is such that the corrective tendency is either too slow or so rapid that the system overcorrects momentarily and thus oscillates back and forth through a level condition, this phenomenon being known in the hydraulic control art as hunting.

It is an important feature of the hydraulic self-leveling arrangement of the present invention that the sensing means which detects and indicates an off-level condition acts mechanically directly upon bleeder valve means for variably bleeding hydraulic fluid from the side of the system that is in advance of the other in the out-of-level condition.

The degree of bleeding is proportionate to the magnitude of the out-of-level condition so that a large deviation calling for a substantial correction results in a substantial opening of the appropriate bleeder valve passage whereas a minor deviation calling for only a small degree of correction produces a proportionately restricted degree of opening of the appropriate bleeder valve.

This relationship between the degree of deviation and the degree or rate of correction results in quick return

of the ram or movable platen directly to a level condition regardless of the magnitude of deviation and without the aforesaid hunting or oscillation which characterizes prior art systems aiming at this general result.

In the form illustrated herein by way of example, the hydraulic equalizing control arrangement of the present invention is twofold. Correction is made as between the hydraulic drive cylinders at opposite sides of the crosshead or reciprocable ram to adjust the relative volumes of hydraulic fluid to or from the two cylinders in response to variations in the level of the crosshead or ram, which variations in the present instance are mechanically measured or indicated as will appear later herein.

A second control used in conjunction with the foregoing bleeder arrangement may be referred to as a pressure control since it equalizes pump pressure to the two cylinders. This pressure control is independent of the mechanical or other means which detects variations in level of the crosshead. The latter adjusts the volume of hydraulic fluid to the two sides to correct for such variations in the level of the crosshead while the second control comprises a pressure equalizing arrangement which establishes and maintains equal pressures at the output sides of the pumps at the opposite sides of the system, not at the operating cylinders, for the purpose of causing the two pumps to direct equal volumes of hydraulic fluid to the two working sides of the system.

Referring to this second control, as distinct from the above mechanical sensing control, when one side of a ram or the like acts against a greater load the pump for that side of the ram is subjected to a greater back pressure and this would normally cause such pump to displace less fluid. The pressure control here under discussion operates under these differential pressure conditions to impose a restriction to the output flow from the pump leading to the lighter loaded side of the ram.

This has the effect of increasing the back pressure against that pump to substantially equalize the back pressures against both pumps. This is in effect cuts down the volumetric output of the lighter loaded pump and thus tends to equalize the volumetric outputs of the two pumps despite the unequal resistances offered by the two hydraulic motors which the two pumps serve.

Reference is had herein to a pair of hydraulic piston and cylinder motor devices but it is to be understood that the principles of the present invention are applicable in a similar manner to any similarly related pair of hydraulic actuators in a system employing more than two actuators as, for instance, where four actuators may be located at the four corners of a hydraulically reciprocated press platen. It is likewise to be understood that the claims appended hereto are applicable to machines employing any number of hydraulic actuators wherein any pair of such actuators are correlated in the manner defined in the claims to correct for unequal movements thereof.

A single embodiment of the principles of the present invention is illustrated schematically in the accompanying drawings and described in the following specification but it is to be understood that such embodiment is by way of illustration only and that various alterations and modifications may be made without departing from the principles of the invention, the scope thereof being limited only as defined in the appended claims.

In the drawings:

FIG. 1 is the upper portion of a diagrammatic view showing schematically one form of the hydraulic operating and control system of the present invention as applied to a press brake;

FIG. 2 is the lower portion of such diagrammatic view; and

FIG. 3 is an enlarged cross sectional view of one of

the hydraulic counterbalance units employed in the present invention.

In the schematic view, the numeral **10** designates the reciprocable crosshead or ram of a press brake and the numerals **11** and **12** designate hydraulic cylinders which overlie the crosshead **10** at opposite sides thereof and are provided with pistons **13** and **14**, respectively, whose lower ends engage the crosshead **10** as at **15** and **16**, respectively, to reciprocate the crosshead by fluid pressure actuation of the pistons **13** and **14** in the cylinders **11** and **12**.

We shall first describe the main fluid circuits from the hydraulic pressure generating means to the cylinders. A pair of vane pumps **20** and **21** (FIG. 2) are driven from a common electric motor **22**, the pumps having intake conduits **24** and **25**, respectively, which draw fluid from a reservoir **26**. The numerals **27** and **28** designate filter units interposed in the intake conduits **24** and **25**.

The numerals **30** and **31** designate output conduits from the pumps **20** and **21**, respectively, and these main conduits lead through several control and pressure regulating valves to the main directional valves, presently to be described.

The main return conduits designated **33** and **34** lead from the above-mentioned main directional valves back to the reservoir **26**. For convenience in following the hydraulic circuits of the present system the foregoing numerals **30** and **31** are applied to the entire main pressure conduits in each case, certain branch conduits which lead therefrom being designated by distinguishing numerals as will appear later herein.

Each pair of main supply pressure and return conduits leads to a main directional valve, the main directional valve for the supply conduit **30** and return conduit **33** being designated **37** and the main directional valve for the supply conduit **31** and return conduit **34** being designated **38**.

The main directional valves **37** and **38** are mechanically interconnected for joint lineal shifting movement by a rod **40** and are actuated in opposite directions by a pilot directional valve **39** which in the present instance is solenoid-controlled to shift between positions for moving the crosshead successively down and up by electrical switch means such as limit switches interposed in the path of the crosshead **10** to be actuated at opposite ends of its stroke.

The schematic drawing shows diagrammatically a representative mechanical arrangement for measuring or sensing out-of-level conditions in the crosshead or ram **10** and for translating such indications or measurements into a proportionate hydraulic fluid flow control impulse. A pair of idler pulleys **42** and **43** are fixed to the crosshead **10** at opposite sides thereof to reciprocate vertically with the crosshead **10** and a further idler pulley **44** is mounted on the machine framework whereby it occupies a relatively fixed position.

A tape or cable element **46** is adjustably anchored at one end to a bracket **47** which is fixed to the machine, screw means **48** being provided for lineally adjusting the attached end of tape **46** to adjust the effective length of the latter. This anchorage is referred to as a "tilt" adjustment. The other end of tape **46** is fixed to a rod **50** which carries a spool valve **51** operating in a valve casing **52**, valve **51** and casing **52** comprising a crosshead level servo-valve.

Spool valve **51** is normally centered as shown in the schematic diagram to close all valve passages thereto. A servo-valve conduit **54** leads indirectly from the right-hand main pressure conduit **31** in a manner which will presently be described and a second servo-valve conduit **55** leads from the left-hand pressure conduit **30** likewise in a manner which will be described later herein. A discharge conduit **56** from the casing **52** leads to either of the return conduits, in the present instance to the return conduit **34**.

It will be noted that the cylindrical central enlargement of spool valve **51** has a line-to-line seal with the discharge passage which leads to discharge conduit **56** and has tapered end faces whereby axial shifting movements thereof in either direction create valve passages of variable flow capacity or variable effective cross sectional area. Accordingly, shifting movements of valve **51** under the impetus of and in accordance with adjusting movements of tape **46** produce valve openings in proportion to the magnitude of tilt of the ram as reflected by varying movements of tape **46**.

In FIG. 1 the numeral **57** designates an abutment through which rod **50** extends and a compression coil spring **58** acts between abutment **57** and a collar **59** carried by rod **50** and urges the attached end of tape **46** to the left as viewed in FIG. 1, thus maintaining the tape under tension.

In the schematic showing a pilot servo for shifting the main directional valves **37** and **38** is designated **60** and includes a piston **61** which is carried by the rod **40** which directly connects the main directional valves. Hydraulic pressure for shifting piston **61** in opposite directions to simultaneously reverse the main directional valves is introduced to the pilot servo **60** by conduits **62** and **63** which lead from the pilot directional valve **39**.

Pilot directional valve **39** includes a multiple spool valve **65** which is biased to the right as shown in the diagram by a spring **66** and is shiftable to the left as there shown when a control electromagnet **67** is energized. Suitable limit switches may be positioned at convenient points on the press to be respectively opened and closed as the ram **10** reaches desired upper and lower limit positions and in the present illustrative instance the arrangement is such that solenoid **67** is energized to begin the down stroke of the ram **10** and remains energized until the ram reaches its lower limit position, whereupon the energizing circuit for solenoid **67** is interrupted by limit switch engagement and valve **65** shifts to the right to bring about the up stroke of ram **10**.

In the schematic showing solenoil **67** is energized and accordingly valve **65** is in its left-hand position. In this position the passages in the pilot directional valve **39** are connected in such a way that a pilot valve operating pressure conduit **70**, which may lead from any convenient source of hydraulic pressure as for instance the main pressure conduit **31**, is connected with the conduit **62** which leads to the left-hand side of the main directional valve operating cylinder **60**. In this position of the pilot valve **39** the other conduit **63** of cylinder **60** connects through the pilot valve to a conduit **71** which empties into return conduit **34**.

From the foregoing it will be seen that at the beginning of and during the down stroke of ram **10** the valve members of the main directional valves **37** and **38** which are designated **74** and **75**, respectively, are in right-hand positions wherein the main supply conduits **30** and **31** connect with conduits **80** and **81** which lead to the upper ends of the cylinders **11** and **12**, respectively, whereas conduits **83** and **84** from the lower ends of the cylinders **11** and **12** are connected by directional valves **37** and **38** to the main return conduits **33** and **34**.

When solenoid **67** of the pilot valve **39** for the directional valves **37** and **38** is deenergized and valve member **65** accordingly shifts to the right the pressure and return connections comprising the conduits **62** and **63** are reversed and main direction valve operating cylinder **60** and piston **61** operate to jointly shift the valve members **74** and **75** of the main directional valves **37** and **38** to the left as shown in the schematic drawing.

Upon such shifting the main pressure supply conduits **30** and **31** are connected to the lower conduits **83** and **84** of the cylinders **11** and **12** and the upper conduits **80** and **81** of these cylinders are connected with the main return conduits **33** and **34**. This establishes the normal up and down hydraulic reciprocation of ram **10** and reference will now be had to the manner in which this

normal reciprocation is modified by the operation of the level control arrangement which performs a part of the present invention.

Speaking generally, when an off level condition exists, as for instance if the right-hand side of the ram **10** should be lower than the left-hand side during a down stroke, the upper end of the tape or cable **46** would be drawn to the right as shown in the diagram an amount linearly equal to the distance that the idler pulley **43** has moved down with respect to the idler pulley **42**.

This moves the blocking valve member **51** of the level servo valve **52** to the right which connects servo valve conduit **54** to the discharge conduit **56** and the degree of fluid connection thus established between these conduits is controlled by the degree which the valve member **51** moves to the right and is made more exactly proportionate to such movement by the tapered end formations of the blocking valve **51** which were described previously herein.

Since servo valve conduit **54** leads from main pressure supply conduit **31** via conduit **92** and valve **90**, which will be described later herein, a proportionately controlled amount of hydraulic fluid is bled from main pressure supply conduit **31** to slow the descent of right-hand piston **14** and consequently bring the ram into a level condition.

If the deviation during a down stroke should be in the opposite direction, the valve member **51** would move to the left from the central position shown in the drawing to bleed fluid from servo valve conduit **55** and consequently from the main pressure supply conduit **30** since conduit **55** connects via valve **90** and conduit **91** with the main pressure supply conduit **30**.

When the ram is moving in an up direction the servo valve conduits **54** and **55** must be oppositely connected with respect to the main pressure supply conduits **30** and **31** to effect the same level restoring function and accordingly a bleeder connection reversing valve **90** is interposed between the servo valve conduits **54** and **55** and a pair of branch conduits **91** and **92** which lead respectively from the main pressure supply conduits **30** and **31**.

The position of valve member **94** of the reversing valve **90** should correspond to the positions of the main directional valves **37** and **38** and for this reason the conduits **62** and **63** which energize the main direction valve operating cylinder **60** are provided with branch passages designated **96** and **97** respectively which cause the valve member **94** of the reversing valve **90** to assume a right or left position in accordance with the positions of the main directional valves **37** and **38**.

In event of abnormal operation beyond the corrective capacity of the foregoing level control device, as when a pump fails or if tape **46** should break, or any other unusual condition should supervene to produce an extreme out-of-level condition or extreme movement of the tape **46** for any other reason, an arm **98** carried by rod **50** will engage one or another of a pair of limit switches **99** and **100** and operate the same to produce a shut-down condition.

Independently of the foregoing level control arrangement the present apparatus provides means which in effect tends to synchronize the volumetric output of the two pumps to avoid a condition, usually due to eccentric loading, wherein one side of the ram has less resistance and thus imposes less back pressure against a given pump with the result that that pump would then normally displace more fluid.

To correct this condition when it arises, equalizing valves **105** and **106** shown in FIG. 2 are interposed in the main pressure supply conduits **30** and **31**. Referring to the valve **105**, a shiftable valve member **107** is normally maintained to the left as viewed in the diagram by a relatively light spring **108**. When pump pressure is applied to the valve **105** fluid pressure in a branch passage **109** shifts the valve member **107** to the right to open the same and establish flow therefrom to the associated directional valve **37**.

A further fluid pressure conduit **110** is arranged to oppose the pressure from the branch passage **109** and this further pressure conduit **110** comes from the other main pressure supply conduit **31**. Accordingly, as resistance builds up under the right-hand side of ram **10** for instance, such resistance would cause a pressure increase in the associated pressure supply conduit **31** which would be communicated to valve **105** through conduit **110**.

As will be seen, this increase in pressure in branch conduit **110** has the effect of preventing a relatively higher volumetric output from the pump **20** which is then under the lightest load insofar as the ram **10** is concerned. This is accomplished by building up the back pressure on the pump **20** to a point where the resistance at the outlet side of that pump is substantially equal to the resistance at the outlet side of the pump **21** which is acting against a greater load insofar as the ram itself is concerned.

The increase in pressure at branch conduit **110** acts against the pressure of fluid in branch conduit **109** and produces a proportionate increase in pressure at the branch conduit **109** and thus results in a pressure increase in main supply conduit **30** since the pump **20** thereof will act to maintain a sufficient preponderance of pressure to maintain the valve **107** in a fully opened condition. In other words the increased pressure thus applied against branch passage **109** by valve **107** imposes a greater load on pump **20** and the corrective action is so proportioned that the back pressure on the two pumps is equalized and accordingly their volumetric output is likewise equalized.

Obviously on a reverse condition of greater resistance under the left-hand side of ram **10** the operation of equalizing valve **106** will correct the relative volumetric outputs from the pumps in an opposite manner. The branch passage from main supply conduit **30** to equalizing valve **106** is designated **112**, the valve thereof **113**, the valve opening branch passage **114**, and the biasing spring **115**.

The foregoing describes the novel combination of the hydraulic leveling system of the present invention, both as to arrangement and construction of the components and as to the operation of the system. Certain additional components shown in the schematic drawings are conventional in hydraulic press systems of this general class apart from the self-leveling arrangement and are illustrated only in the interests of disclosing a fully operative system. The details, operation and functions of these additional components will be readily recognized and understood by those skilled in the present art.

In FIG. 2 the numerals **120** and **121** designate a pair of high pressure relief valves which are interposed in the main pressure conduits **30** and **31**, respectively, and are provided with a conventional high pressure vent valve **122**. Vent passages from the high pressure relief valves **120** and **121** to the vent valve **122** are designated **124** and **125**, respectively, and are connected to the reservoir by a discharge conduit **126** from the vent valve when the operating electromagnet of the latter is deenergized.

The operating electromagnet of vent valve **122** is designated **123** and is selectively energized and deenergized by the machine operator by a manual or pedal operated switch (not shown), which comprises the main operator control for starting and stopping the machine. When the machine is in operation in the performance of a downstroke or return stroke because the electromagnet **123** of vent valve **122** is energized and the vent passages **124**, **125** are blocked. Under these conditions the relief valves **120** and **121** will bypass through relief conduits **129** and **130**, respectively, only when the desired maximum pressure is exceeded.

However, when the motion of ram **10** ceases because the electromagnet of vent valve **122** is deenergized, the vent passages **124** and **125** are connected to discharge

conduit **126** by valve **122**, and the valves **120** and **121** are automatically vented so that fluid thereto from conduits **30** and **31** is entirely bypassed to reservoir **26** through conduits **129** and **130**.

In FIG. 2 the numerals **132** and **133** designate conventional check valves in conduits **30** and **31**, respectively, which prevent retrograde fluid flow in those conduits for the usual reasons.

In FIG. 1 the numerals **135** and **136** designate a pair of adjustable counterbalance valves interposed in the conduits **83** and **84**, respectively, which lead from the lower ends of the cylinders **11** and **12**. The internal structure of counterbalance valve **135** is shown in FIG. 3 although these valves are conventional and perform the same function in the present combination as in prior art hydraulic press brakes or similar machines. The valves **135** and **136** are adjusted to impose a yieldable hydraulic resistance equal in effect to the weight of the ram **10** and the die or other parts carried thereby or that move up and down therewith.

The manner in which the self-levelling means operating through the medium of the conduits **54** and **55** cooperates with the pump output pressure equalizing means which operates through the equalizing valves **105** and **106** is as follows. Out-of-level conditions may arise from various sources but a common normal cause would be unequal or eccentric loading or resistances at opposite sides of ram **10**. In such case the immediate symptom would be an increase in back pressure on the pump at the side of the ram which is acting against a greater resistance. Thus the valves **105** and **106** operate to ameliorate the potential off-level condition by imposing an augmented resistance to the lighter loaded pump through the cooperation of the valves **105** and **106** as previously described. Thus the potentiality for an out-of-level condition would be reduced.

Since some out-of-level condition may and probably will ensue despite this corrective tendency of the valves **105** and **106**, the level equalizing means operating by way of the conduits **54** and **55** is set into operation immediately upon the existence of an out-of-level condition to correct the same in the manner described above. Thus it may be said that in the case of eccentric loading the pressure equalizing means reduces the out-of-level potentiality and the level control means eliminates the resultant reduced out-of-level condition.

In addition to the foregoing cooperation of the two corrective components, each may perform more or less individually under certain other conditions. For instance, out-of-level conditions may arise for reasons other than unequal loading in which case the level control means may and often will operate without the intervention of the pump output pressure control means.

We claim:

1. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, sensing means movable in opposite directions in response to unequal movements of laterally spaced points on said movably mounted member in proportion to the degree of said unequal movements, bleeder conduits from said pump outlet passages, and bleeder valve means openable proportionately in response to varying movements of said sensing means to bleed fluid at proportionately varied rates from one or the other of said bleeder conduits, reversing valve means connecting across said bleeder conduits to reverse the connections of said pump outlet passages to said bleeder valve means, said bleeder conduit reversing valve means being connected for operation with said first mentioned reversing valve means.

2. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising pressure regulating valve means in each pump outlet passage, actuating means connected to said pressure regulating valve means, and a connection from each pump outlet passage beyond the regulating valve means thereof to said actuating means of the other outlet passage to adjust the regulating valve means thereof to increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

3. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising means in each pump outlet passage for imposing a variable back pressure on such pump and a connection from each pump outlet passage beyond the variable back pressure means thereof to the variable back pressure means of the other passage to regulate the fluid pressure in the latter and thus increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

4. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, sensing means movable in response to out of level condition of said movably mounted member, bleeder conduits from said pump outlet passages, bleeder valve means operable by said sensing means to bleed fluid from one or the other of said bleeder conduits, and reversing valve means connecting across said bleeder conduits to reverse the connections of said

pump outlet passages to said bleeder valve means, said bleeder conduit reversing valve means being connected for operation with said first mentioned reversing valve means.

5. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, and the outlet passage directed to one of said motors, sensing means movable in opposite directions in response to unequal movements of laterally spaced points on said movably mounted member in proportion to the degree of said unequal movements, bleeder conduits from said pump outlet passages, bleeder valve means openable proportionately in response to varying movements of said sensing means to bleed fluid at proportionately varied rates from one or the other of said bleeder conduits, and means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising pressure regulating valve means in each pump outlet passage, actuating means connected to said pressure regulating valve means, and a connection from each pump outlet passage to said actuating means of the other outlet passage to adjust the regulating valve means thereof to increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

6. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, sensing means movable in opposite directions in response to unequal movements of laterally spaced points on said movably mounted member in proportion to the degree of said unequal movements, bleeder conduits from said pump outlet passages, bleeder valve means openable proportionately in response to varying movements of said sensing means to bleed fluid at proportionately varied rates from one or the other of said bleeder conduits, reversing valve means connecting across said bleeder conduits to reverse the connections of said pump outlet passages to said bleeder valve means, said bleeder conduit reversing valve means being connected for operation with said first mentioned reversing valve means, and means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising pressure regulating valve means in each pump outlet passage, actuating means connected to said pressure regulating valve means, and a connection from each pump outlet passage to the actuating means of the other outlet passage to adjust the regulating valve means of the other passage to bias the latter and thus increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

7. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, sensing means movable in response to out of level condition of said movably mounted member, bleeder conduits from said pump outlet passages, bleeder valve means operable by said sensing means to bleed fluid from one or the other of said bleeder conduits, reversing valve means connecting across said bleeder conduits to reverse the connections of said pump outlet passage to said bleeder valve means, said bleeder conduit reversing valve means being connected for operation with said first mentioned reversing valve means, and means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising pressure regulating valve means in each pump outlet passage, actuating means connected to said pressure regulating valve means, and a connection from each pump outlet passage to the actuating means of the other outlet passage to adjust the regulating valve means of the other passage to bias the latter and thus increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

8. In a machine having a member of substantial width movable toward and away from an opposed member, a pair of hydraulic motors adapted to act simultaneously against laterally spaced points on said movably mounted member to reciprocate the same, a pump for each of said motors having inlet and outlet passages with the inlet passage connected to a hydraulic fluid reservoir, a pair of conduits to each motor for conducting fluid to actuate the same in opposite directions, and reversing valve means for each motor connecting the associated pump outlet passage to one of said conduits and the other of said conduits to said reservoir and vice versa, means for simultaneously shifting the reversing valve means of each of said motors to reverse said motors, sensing means movable in opposite directions in response to unequal movements of laterally spaced points on said movably mounted member in proportion to the degree of said unequal movements, bleeder conduits from said pump outlet passages, bleeder valve means openable proportionately in response to varying movements of said sensing means to bleed fluid at proportionately varied rates from one or the other of said bleeder conduits, and means for equalizing the back pressure on said pumps to equalize their volumetric outputs under unequal loading thereof, said means comprising pressure regulating valve means in each pump outlet passage, actuating means connected to said pressure regulating valve means, and a connection from each pump outlet passage to the actuating means of the other outlet passage to adjust the regulating valve means of the other passage to bias the latter and thus increase the back pressure on the lighter loaded pump to substantially equal the back pressure on the heavier loaded pump.

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