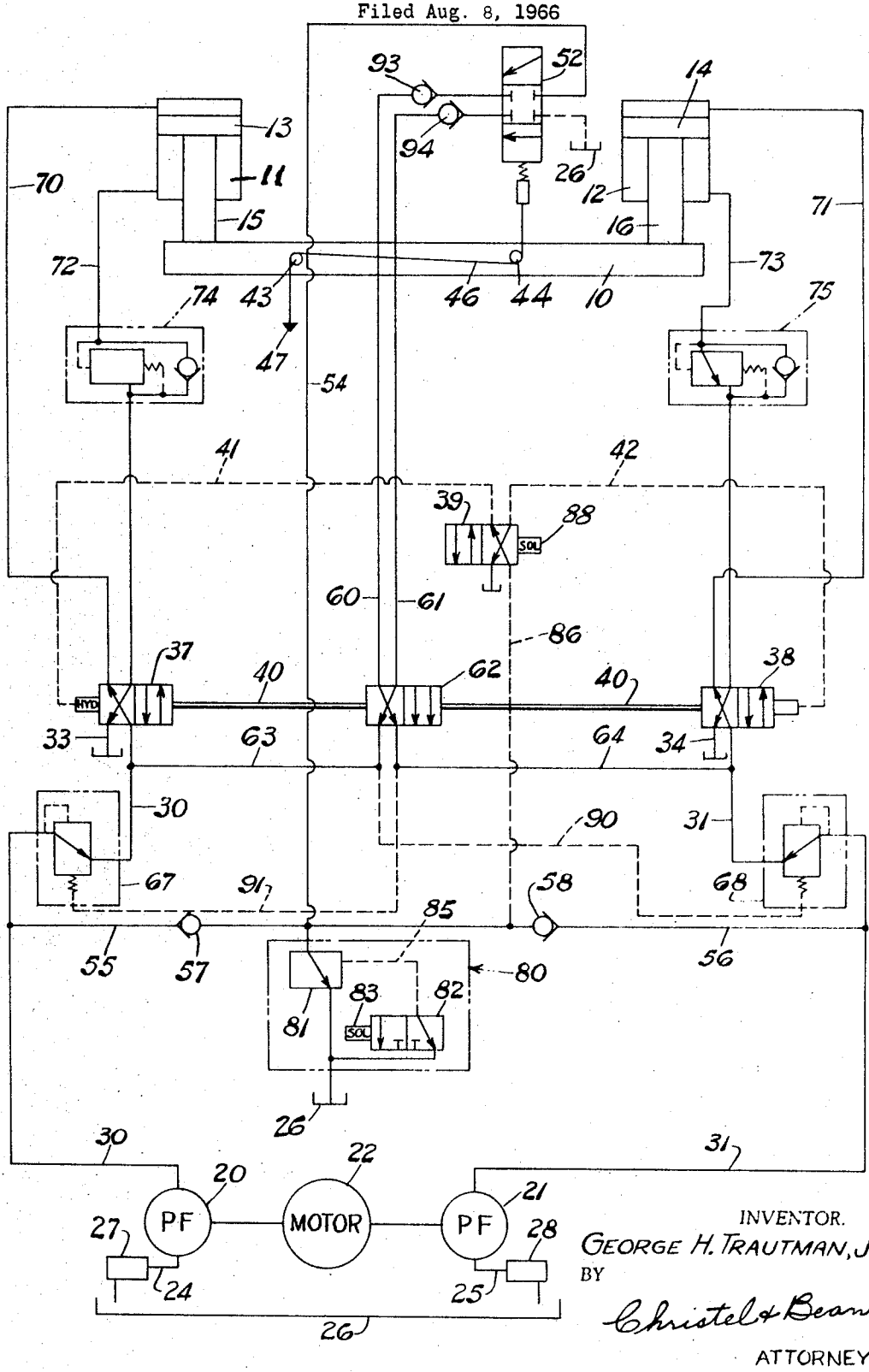
Sept. 30, 1969 G. H. TRAUTMAN, JR 3,469,435

LEVEL CONTROL FOR HYDRAULIC PRESS BRAKES AND THE LIKE

Filed Aug. 8, 1966



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United States Patent Office 3,469,435
Patented Sept. 30, 1969

3,469,435

LEVEL CONTROL FOR HYDRAULIC PRESS BRAKES AND THE LIKE

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Filed Aug. 8, 1966, Ser. No. 571,032
Int. Cl. B21j 9/14
U.S. Cl. 72—453 16 Claims

ABSTRACT OF THE DISCLOSURE

A level control for a machine having a member of substantial width movable toward and away from an opposed member by means of a pair of hydraulic motors which act simultaneously against laterally spaced points on the movable member when supplied with operating pressure fluid through a pair of supply conduits from a pump. A valve is provided with a pair of outlet conduits to the supply conduits and an input conduit to the pump. The valve is normally blocked but shiftable to supply additional pressure fluid from the input conduit to the supply conduit of whichever of the motors is lagging, in response to the operation of mechanical means connected to the movable member for sensing unequal movements of laterally spaced points thereon.

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 a ram or movable platen is reciprocated by hydraulic motor means.

In hydraulic press brakes and other hydraulic presses or shears 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.

In the prior art various levelling arrangements for hydraulic machines of this type have been proposed and employed wherein level-sensing means controls a valve which, upon the occurrence of an out-of-level condition, bleeds hydraulic fluid from the leading cylinder whereby its movement is retarded until the pair of cylinders are again in synchronism. Examples of arrangements of this type are found in Castle Patent No. 2,558,071, Hazelton et al. Patent No. 2,978,976 and Munschauer et al. Patent No. 3,059,431.

While bleeding fluid from the leading cylinder has been generally adopted for automatic levelling of cylinders in the hydraulic press brake field, this exepdient is subject to numerous practical objections and difficulties. First, there is an obvious inefficiency in draining fluid from the hydraulic system which is unavoidable in attaining automatic leveling in this manner. Secondly, these bleeding arrangements are prone to starting difficulties after the machine has been idle for some time. The cause of this

difficulty is not known but appears to result from slow drainage or siphonage of fluid through the bleed valve, especially if the machine is stopped when not exactly level or when one side drifts slightly out of level during idle periods.

Furthermore, in this prior art system, when one side of a ram or crosshead drifts downwardly the condition is not corrected since the other side cannot drain freely due to the presence of conventional counterbalance valves in each side of the system.

The present levelling system accomplishes the desired purposes without adding or substracting fluid from the system which supplies fluid to the two cylinders. Means are provided whereby, when an out-of-level condition arises, a proportionately greater amount of the fluid supply is automatically directed to the cylinder at the lagging side. More specifically, this is accomplished by actually adding fluid to the conduit which supplies fluid to the cylinder at the lagging side to cause the piston of such cylinder to advance to a position of synchronism with the piston of the other cylinder.

This novel arrangement avoids many objections which accompany prior art arrangements. The above mentioned starting difficulties are avoided since the positive pressure applied by way of the level compensating valve insures a fully pressured system. Also, when the machine is idle with the pumping system running, the by-pass pressure is sufficient to maintain the ram or platen in a level raised position. Furthermore, full operating pressure is maintained since there is no impoverishment of the system due to bleeding fluid therefrom.

While a single specific embodiment of the principles of the present invention is illustrated in the accompanying drawing and described in detail in the following specification, it is to be understood that such embodiment is by way of example only and that various mechanical modifications may be made without departing from the spirit of the invention the scope of which is limited only as defined in the appended claims.

The single figure of the drawing is a schematic showing of one form of the hydraulic drive and self-leveling system of the present invention.

In the drawing, the numeral **10** designates the usual 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 pumps **20** and **21** 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 showing of the reservoir **26** is repeated at various parts of the diagram merely for simplicity of illustration, it being understood that the various reservoir indications **26** constitute in fact one common reservoir. 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**.

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 sup-

ply conduit **31** and return conduit **34** being designated **38**. The valves **37** and **38** are conventional four way pilot-operated valves.

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 connections from pilot valve **39** to the pilot operated directional valves **37** and **38** are designated **41** and **42**, respectively..

The schematic drawing shows digrammatically a representative mechanism 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 **43** and **44** are fixed to the crosshead **10** at opposite sides thereof to reciprocate vertically with the crosshead **10**.

A tape or cable element **46** is adjustably anchored at one end to a bracket **47** which is fixed to the machine. Bracket **47** may include mechanism such as is shown at **47** and **48** in FIG. 1 of Munschauer et al. Patent No. 3,059,431 to establish an initial level setting of valve **52** and to provide predetermined tilt adjustment where desired. The other end of tape **46** is fixed to a spool valve element of a three position closed center directional valve **52**.

The spool valve element of valve **52** is normally centered to close all valve passages and the manner in which it functions to correct out-of-level conditions of the press ram will presently be described.

Operating pressure for valve **52** is provided by a conduit **54** which leads from conduits **55** and **56** from the main supply conduits **30** and **31**, respectively. The conduits **55** and **56** include check valves **57** and **58** which permit fluid flow to conduit **54** from either of the supply conduits **30** or **31** but prevent retrograde flow. Fluid pressure for leveling ram **10** is supplied through either of conduits **60** and **61** from valve **52**, depending upon the direction of deviation of ram **10** as sensed by tape **46**. Conduits **60** and **61** lead to a reversing valve **62** which is connected to rod **40** so that valve **62** reverses with directional valves **37** and **38** and the system thus levels ram **10** with equal efficacy on both the down and up strokes of ram **10**. Conduits **63** and **64** from reversing valve **62** lead to pressure supply conduits **30** and **31**.

In the diagram the numerals **67** and **68** designate pressure control valves interposed in pressure supply conduits **30** and **31**, the operation of which in ram leveling operation will presently be described. The valves **67** and **68** are commercially known as sequence valves which are pressure reducing valves of a particular type which reduce the pressure coming from supply conduits **30** and **31** by a predetermined amount so that the pressure at the outlet side of each valve **67** and **68** is always less than the pressure at the inlet side by a constant amount, for instance, 100 p.s.i.

The conduits from the directional valves **37** and **38** to the upper ends of cylinders **11** and **12** are designated **70** and **71**, respectively, and the conduits, from the directional valves to the lower ends of cylinders **11** and **12** are designated **72** and **73**, respectively. Conventinal counterbalance valves **74** and **75** are interposed in conduits **72** and **73** and are adjusted to counterbalance the weight of ram **10** and the die or other parts carried thereby.

The unit designated generally **80** in the drawing is a control unit for initiating operating cycles of the system and includes a pressure relief valve **81** and a two-way solenoid operated valve **82** having an operating solenoid **83**. As shown in the diagram the system is in idle position and the output of pumps **20** and **21** goes by way of conduits **30**, **31** and **55**, **56** to relief valve **81**, thence directly to the reservoir **26**. A drain passage **85** from valve **81** leads to a two-way valve **82** which causes valve **81** to dump directly to reservoir **26** when valve **82** is in the position shown. Pressure relief valve **81** may be set to maintain a desired minimum pressure in conduits **30**, **31** and **55**, **56**, say 75 p.s.i., for the purpose of supplying operating pressure for various auxiliary purposes such as for supplying pilot pressure to a conduit **86** which leads to valve **39** and thus supplies pilot operating pressure to directional valves **37** and **38**.

When solenoid **83** is operated to initiate movement of ram **10** valve **82** shifts to block drain passage **85** and full output pressure of pumps **20** and **21** is applied to pressure reducing valves **67** and **68**. In the drawing the directional valves **37** and **38** are positioned to effect downward movement of ram **10**. The valves **37** and **38** are controllable as to direction by a solenoid **88** of pilot valve **39** and solenoid **88** is arranged to be operated either manually or automatically by limit switches positioned on the machine so as to be engaged by ram **10** at desired upper and lower limits of movement, this general switch arrangement being conventional.

Levelling operation of the foregoing system will now be described in connection with downward movement of ram **10** although it is to be understood that levelling will be similarly attained during upward movement due to the shifting of reversing valve **62** which accompanies shifting of the directional valves **37** and **38**. Levelling operation is controlled by valve **52** which is a servo-valve of the general type described in Munschauer et al. Patent 3,059,431, and illustrated therein at **52** in FIG. 1.

As shown in this patent, the valve spool which controls the flow of fluid from the pressure conduit **54** of valve **52** to either of the outlet conduits **60** or **61** has a line-to-line seal with the discharge passages and is so constructed that shifting movement of the valve spool in either direction establishes fluid flow of variable quantity to a conduit **60** or **61** proportionally to the degree of shifting movement of the valve spool.

However, apart from this mechanical similarity in the servo-valves as to proportional flow, the valve **52** of the present application differs fundamentally from the corresponding valve of the foregoing patent in that the valve of the patent is merely a bleed valve for discharging fluid from either side of the system to drain, whereas the valve **52** of the present application has a pressure supply conduit connection **54** which is arranged to supply a fluid pressure which is at all times in excess of the pressure obtaining in the conduits **30** and **31** between the pressure reducing valves **67** and **68** and the directional valves **37** and **38**. Check valves **93** and **94** are interposed in conduits **60** and **61** and it will be noted that the static pressure in conduits **63** and **64** and in conduits **60** and **61** between conduits **63** and **64** and the check valves will be the same as in the conduits **30** and **31**, respectively.

Due to this greater pressure in conduit **54**, any shifting of the spool element of valve **52** in response to movement of tape **46** in one direction or another due to out-of-level condition establishes proportional pressure flow from conduit **54** past one or the other of check valves **93** and **94**, to the corresponding conduit **60** or **61** and thence through the corresponding conduit **63** or **64** to the appropriate main pressure conduit **30** or **31**. Since conduits **30** and **31** are between the pressure reducing valves **67** and **68**, respectively, and the associated directional valve **37** or **38**, this superior fluid pressure from levelling pressure conduit **54** causes fluid flow into the conduit **30** or **31**, as the case may be, and thus corrects the out-of-level condition by producing a relative advancement of the position of either piston **13** or piston **14**, whichever is lagging.

In addition to establishing the required reduction of pressure in conduits **30** and **31** as described previously herein, the pressure reducing valves **67** and **68** also serve

to synchronize the volumetric output of the two pumps **20** and **21** to avoid a condition, usual to eccentric loading, wherein one side of the ram has less resistance and thus imposes less back pressure against one of the pumps, which pump will then normally displace more fluid. For this purpose the fluid pressure of conduit **30** is transmitted by way of conduit **63** and a pilot connection **90** as a biasing pressure to the reducing valve **68** at the other side of the system and, conversely, fluid pressure from operating conduit **31** is transmitted by way of conduit **64** and a pilot connection **91** to serve as a regulating pressure against pressure reducing valve **67**.

This arrangement causes an increase in the back pressure against the pump bearing the lighter load and this corrective action is proportioned so that the back pressure on the two pumps is equalized and their volumetric output is thus equalized. This corrective action is merely auxiliary to the previously described arrrangement for introducing supplemental corrective fluid into either of conduits **30** or **31** to correct an out-of-level condition by advancing the lagging piston through such pressure introduction and thereby synchronize the pistons **13** and **14**.

It will be noted that check valves **93** and **94** in the conduits **60** and **61** from servo-valve **52** prevent retrograde flow from either of the conduits **60** or **61** to the outlet ports of the servo-valve.

I claim:

1. In a hydraulic press brake, a frame and a reciprocable ram carried thereby, a pair of hydraulic piston and cylinder mechanisms acting between said frame and spaced points along said ram and operable to reciprocate the latter, a ram level control comprising means to detect advancement of one of said mechanisms beyond the other, a fluid pressure source and a conduit therefrom to each of said mechanisms, an auxiliary conduit containing additional pressure fluid, and means responsive to said detecting means upon advancement of one of said mechanisms beyond the other for supplying additional pressure fluid from said auxiliary conduit to said other mechanism to restore the mechanisms to alignment with each other.

2. Apparatus according to claim **1** including pressure reducing valves in each of the conduits to said piston and cylinder mechanisms, said additional pressure fluid supply being connected with said conduits between said pressure reducing valves and said mechanisms.

3. Apparatus according to claim **2** wherein said additional pressure fluid supply is connected to receive fluid pressure from said fluid pressure source in advance of said pressure reducing valves whereby the pressure thus received is greater than the pressure in said conduits beyond said reducing valves.

4. Apparatus according to claim **1** wherein said responsive means comprises a valve having a pair of outlet passages leading to the conduits to said mechanisms, and check valves in said passages preventing fluid flow toward said valve.

5. Apparatus according to claim **2** wherein said responsive means comprises a valve having a pair of outlet passages leading to the conduits to said mechanisms, and check valves in said passages preventing fluid flow toward said valve.

6. Apparatus according to claim **3** wherein said responsive means comprises a valve having a pair of outlet passages leading to the conduits to said mechanisms, and check valves in said passages preventing fluid flow toward said valve.

7. Apparatus according to claim **1** wherein the conduits to said mechanisms each include reversing valves and passages from said reversing valves to opposite ends of the cylinders of said mechanisms.

8. Apparatus according to claim **7** wherein said responsive means includes pressure supply passages to each of the conduits to said mechanisms, said supply passages including reversing valve means operating jointly with the reversing valves of the conduits to said piston and cylinder mechanisms.

9. Apparatus according to claim **2** wherein the conduits to said mechanisms between said reducing valves and said mechanisms include reversing valves and passages therefrom to opposite ends of the cylinders of said mechanisms.

10. Apparatus according to claim **9** wherein the responsive means includes pressure supply passages to each of the conduits of said mechanisms between said reducing valves and said reversing valves.

11. Apparatus according to claim **10** wherein said pressure supply passages include reversing valve means operating jointly with the reversing valves of said mechanisms.

12. 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, pump means having a pair of outlet conduits for supplying operating pressure fluid to said motor, means for sensing unequal movements of laterally spaced points on said movably mounted member, valve means having a pair of outlet passages to said pressure supply conduits and a pressure conduit from said pump means to said valve, said valve being normally blocked but shiftable to supply pressure fluid from said last mentioned conduit to either of said valve means outlet conduits in response to operation of said sensing means to thereby add operating fluid to either of said motor operating pressure supply conduits to advance the associated motor to synchronism with the other motor.

13. Apparatus according to claim **12** including pressure reducing valves in each of said pump means outlet conduits, said valve means outlet passages connecting with said pressure supply conduits at the outlet reduced pressure sides of said reducing valves.

14. Apparatus according to claim **12** wherein said valve means outlet passages contain check valves preventing fluid flow toward said valve means from said passages.

15. Apparatus according to claim **12** wherein said valve means opens proportionately to varying degrees of movement of said sensing means to add operating fluid to either of said motor operating conduits in proportion to the degree of unequal movement as detected by said sensing means.

16. Apparatus according to claim **1** wherein said responsive means comprises a valve having a pair of outlet passages leading to the conduits of said mechanisms, said valve being arranged to deliver pressure fluid to one or the other of said outlet passages in proportion to the degree of error sensed by said detecting means.

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U.S. Cl. X.R.

100—258