United States Patent [19]

Richardson

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[54] **PRECISION ANTI-WHIP RAM TYPE MACHINE**

[75] Inventor: **Rolland A. Richardson,** Alameda, Calif.

[73] Assignee: **Pacific Press & Shear Corporation**

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[52] **U.S. Cl.** ....**91/170 R,** 91/171, 91/411 R, 60/52 HF, 60/97 E

[51] **Int. Cl.** **F15b 11/16**

[58] **Field of Search** .60/52 HF, 97 G; 91/170 R, 171, 91/411 R, 411 B

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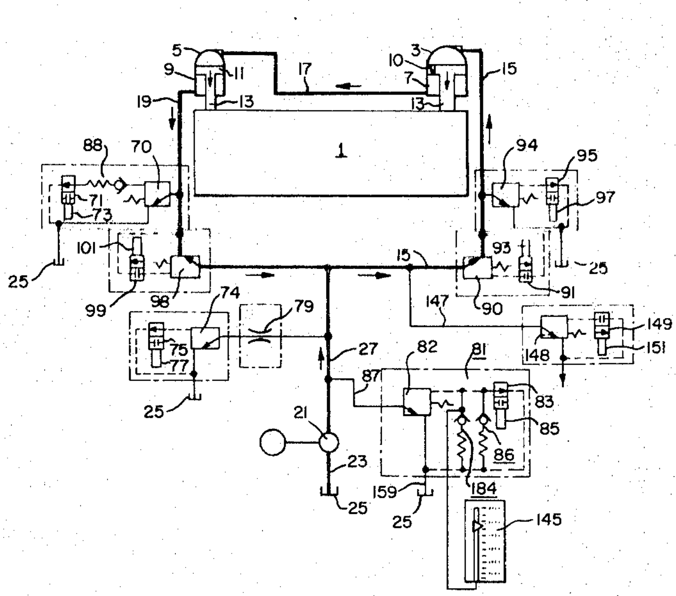
Primary Examiner—Edgar W. Geoghegan
Attorney—Edward Brosler

[57] **ABSTRACT**

A hydraulically powered ram type machine employing series connected hydraulic drive motors, drives the ram at faster than normal speed, then through normal speed following engagement with the work, to a slower than normal speed sufficient to assure extreme accuracy in air bending, and, at the same time, preclude whipping of the work.

14 Claims, 12 Drawing Figures



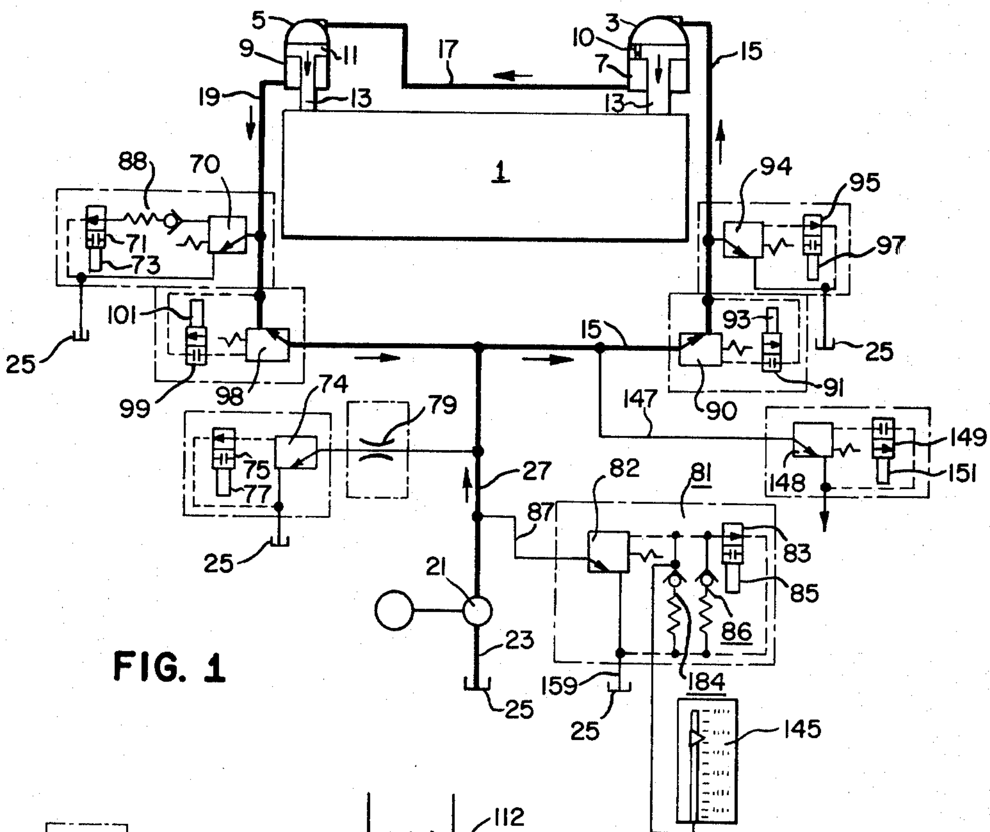


FIG. 1

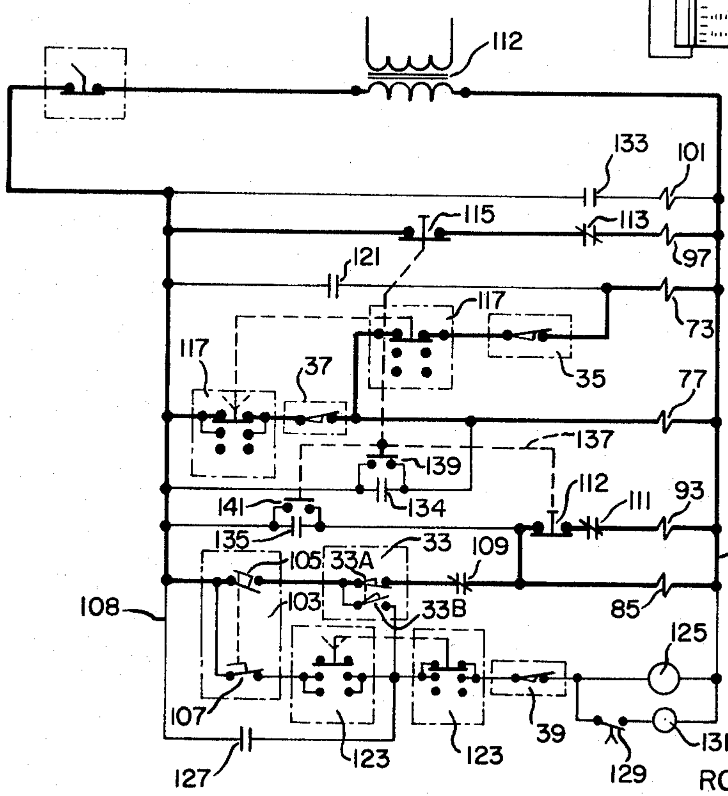


FIG. 2

INVENTOR.
ROLLAND A. RICHARDSON

BY
Edward Brosler
ATTORNEYS

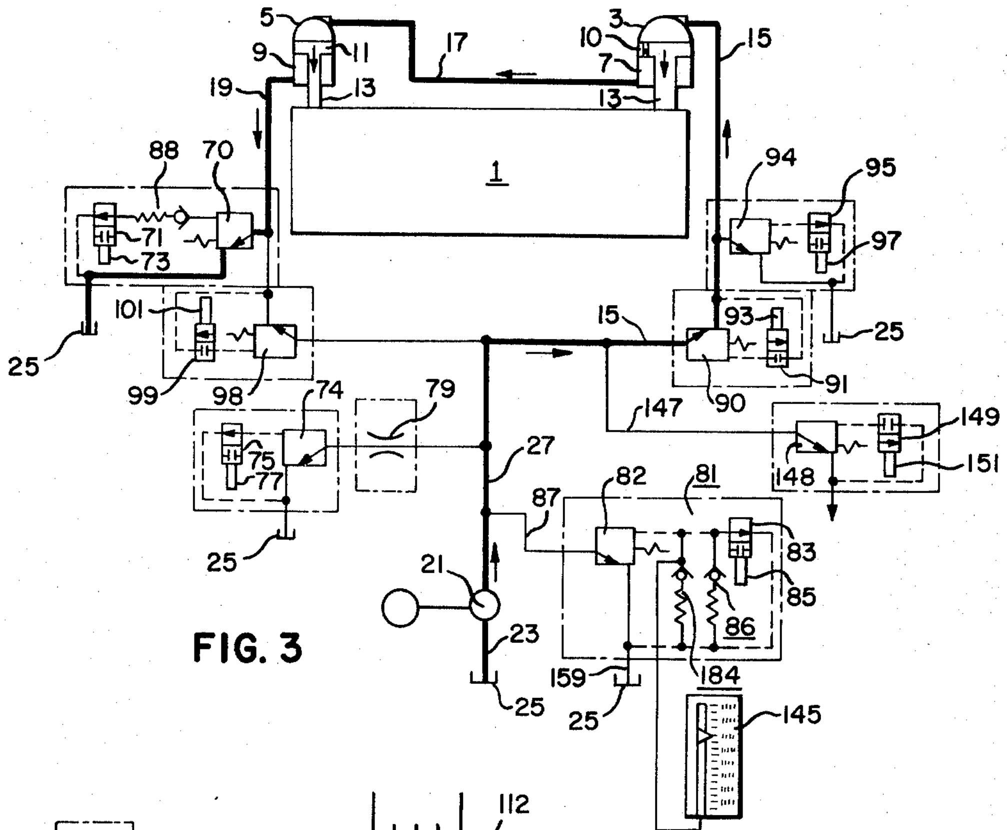


FIG. 3

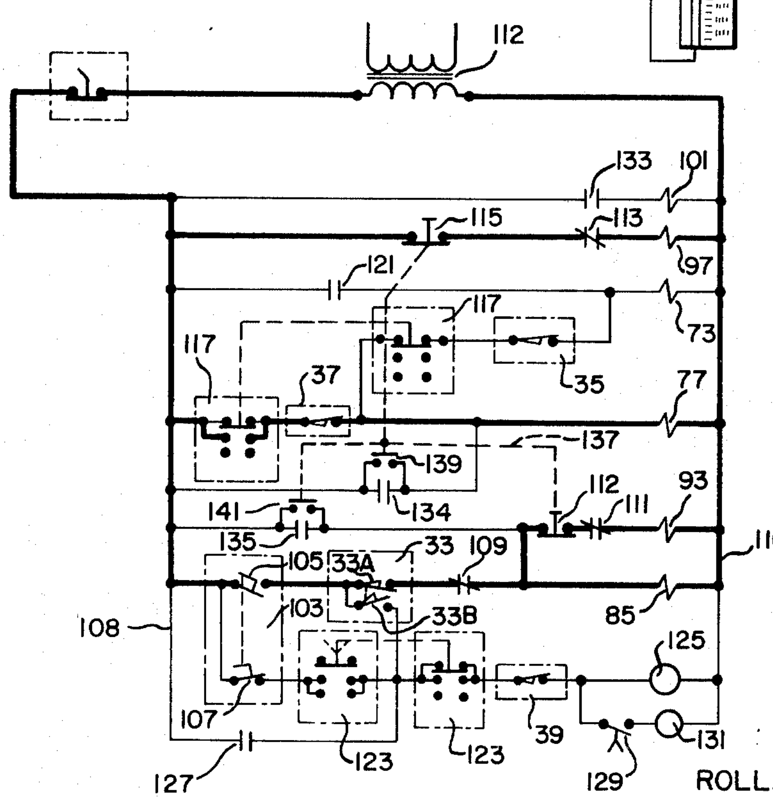


FIG. 4

INVENTOR.
ROLLAND A. RICHARDSON
BY
Edward Brosler
ATTORNEYS

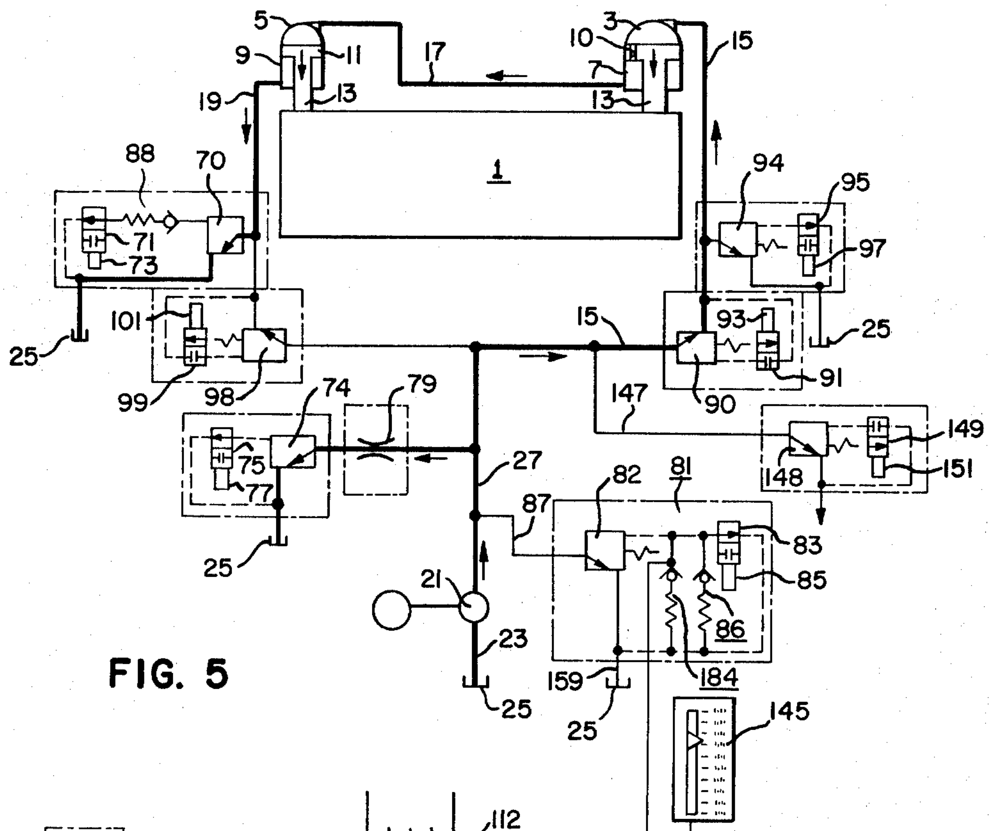


FIG. 5

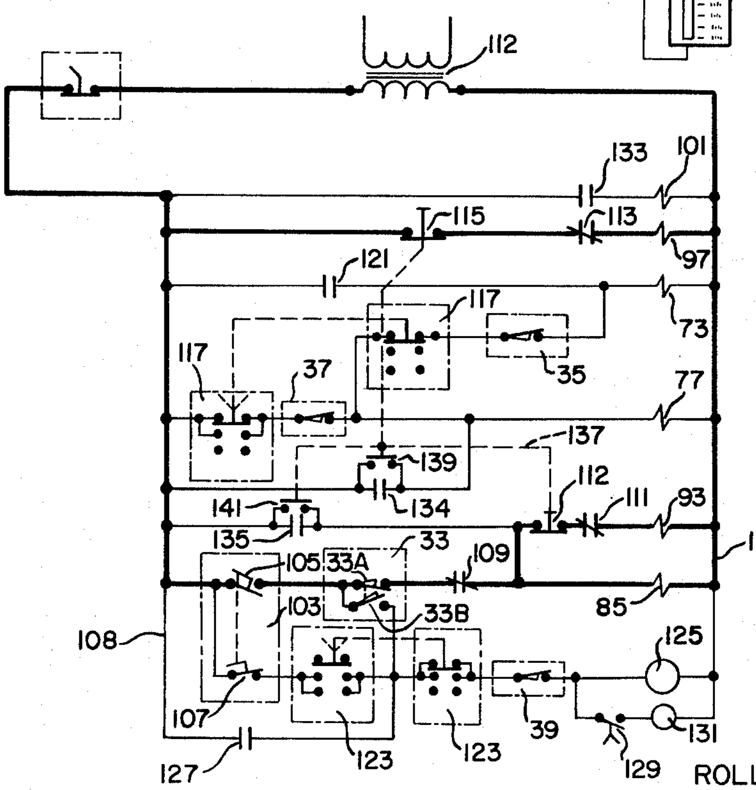


FIG. 6

INVENTOR.
ROLLAND A. RICHARDSON

BY

Edward Brosler

ATTORNEYS

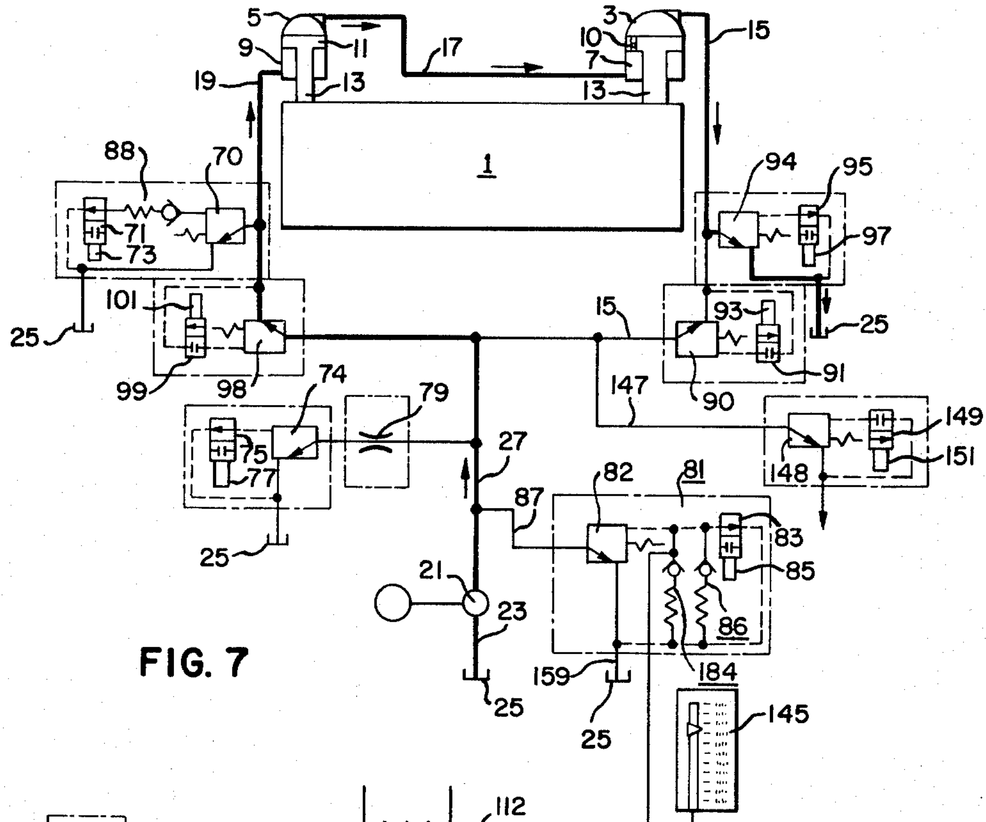


FIG. 7

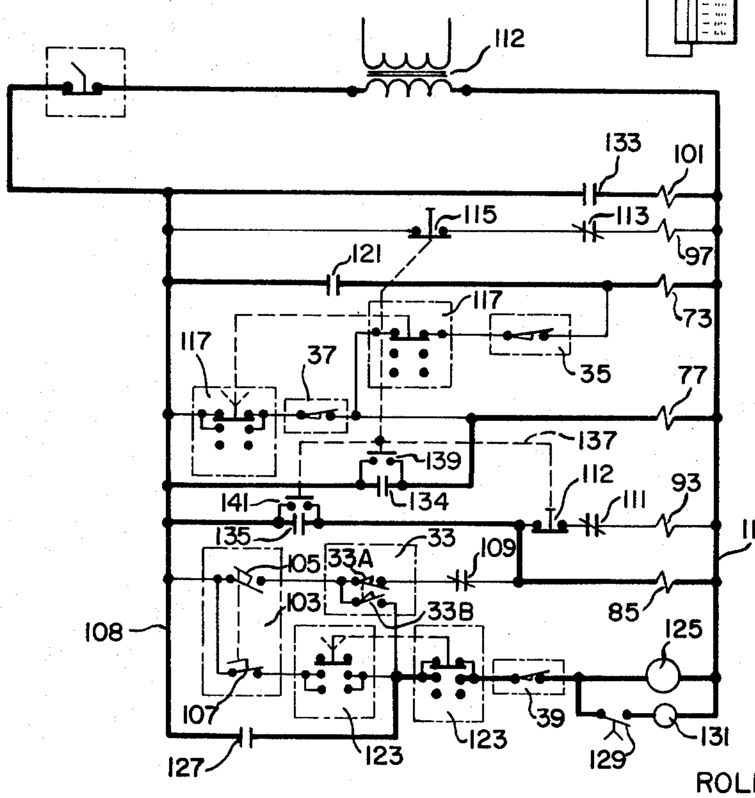


FIG. 8

INVENTOR.
ROLLAND A. RICHARDSON
BY
Edward Brosler
ATTORNEYS

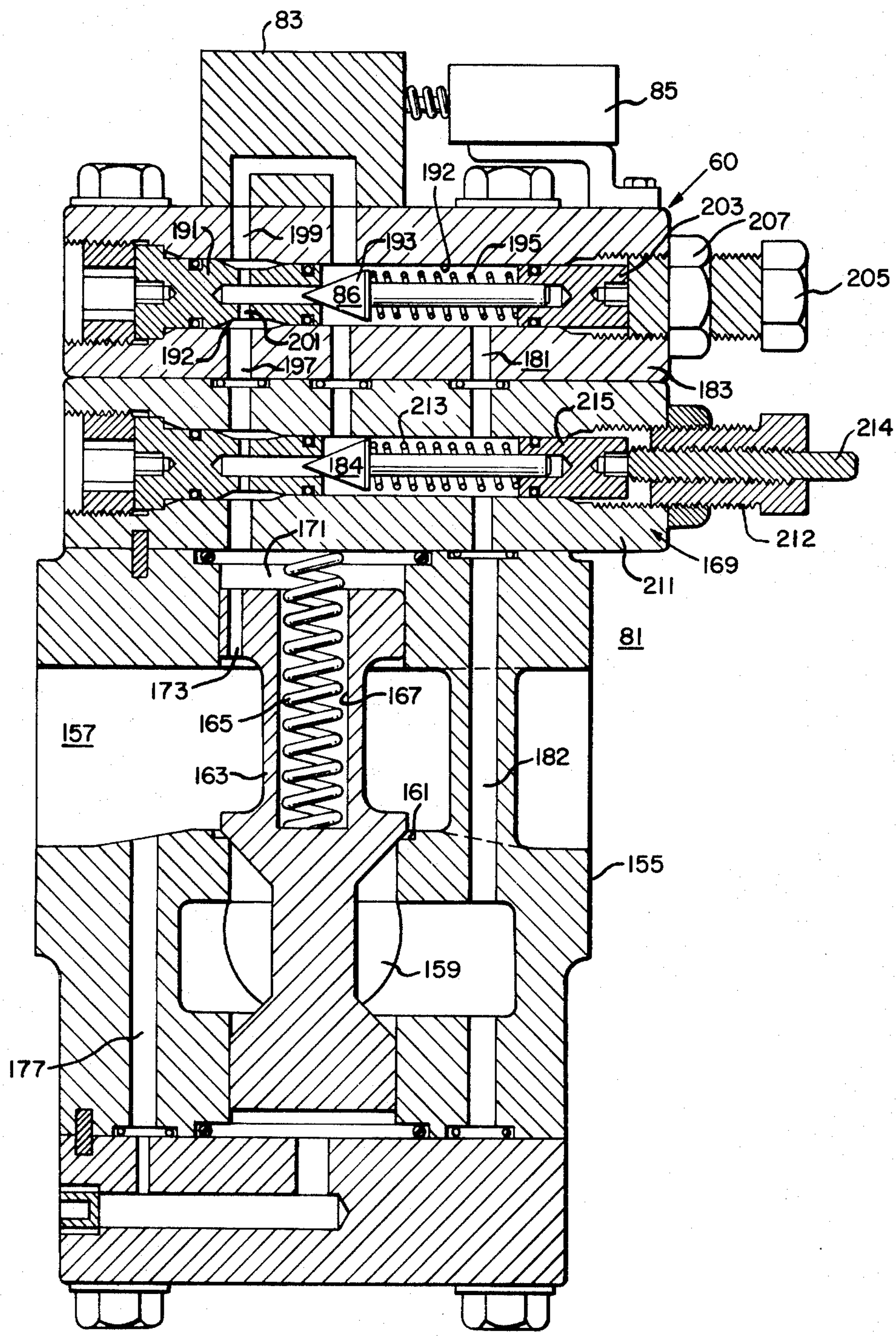


FIG. 9

INVENTOR.
ROLLAND A. RICHARDSON
BY
Edward Brosler
ATTORNEYS

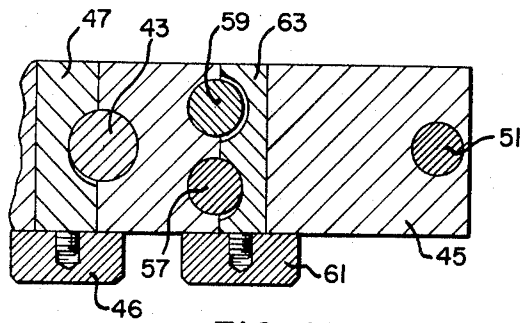


FIG. 11

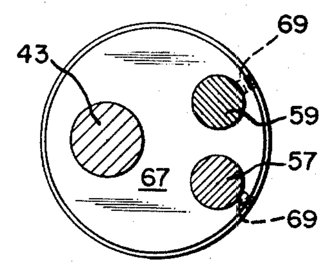


FIG. 12

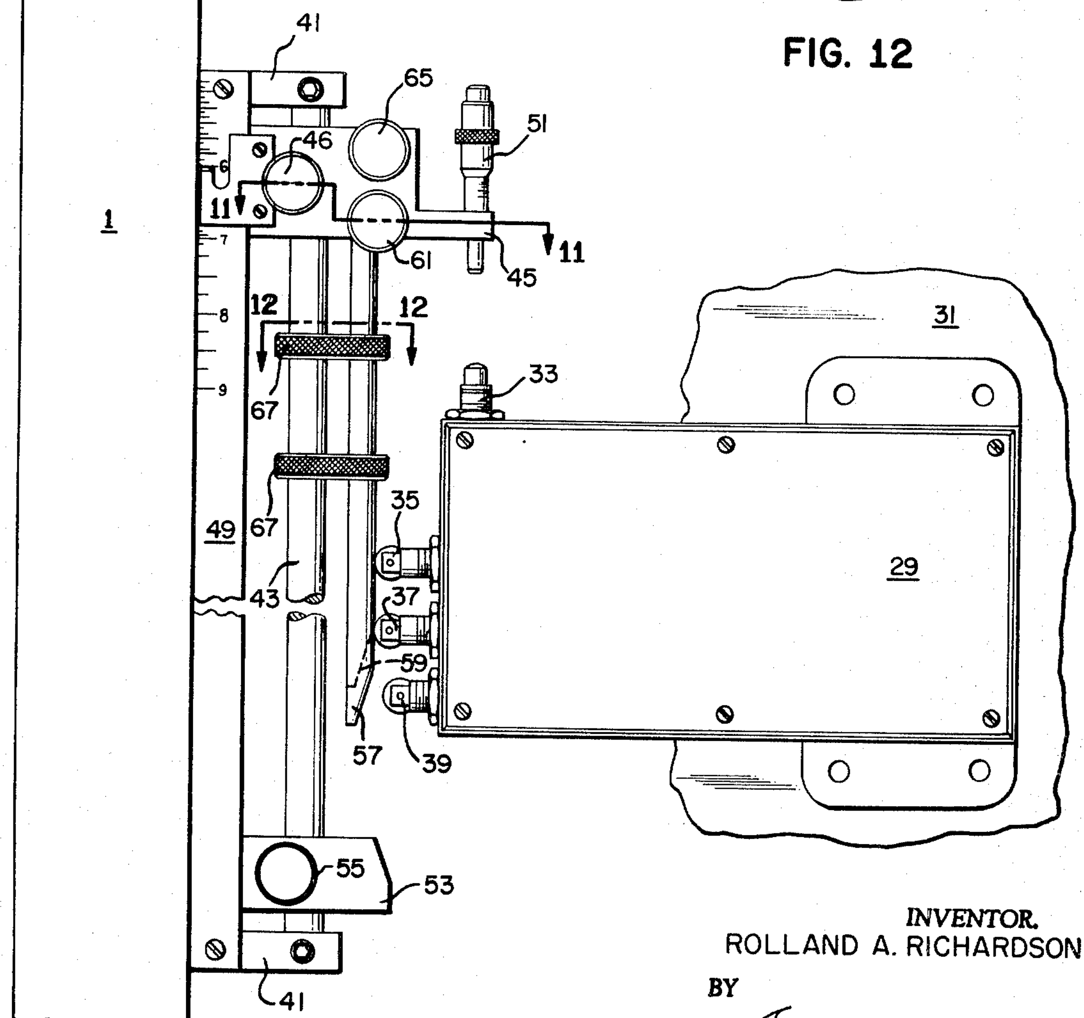


FIG. 10

INVENTOR.
ROLLAND A. RICHARDSON
BY
Edward Brosler
ATTORNEYS

PRECISION ANTI-WHIP RAM TYPE MACHINE

My invention relates to ram type machines and more particularly to the control of movement of the ram in a series system and will be described in connection with the application of the invention to a press brake.

An important function to be performed by a press brake involves the bending of relatively large panels or long strips of metal by the impact of the ram on the work piece where the ram penetrates to a predetermined depth in a die, short of the bottom of the die. This is referred to as air bending, which requires extreme accuracy in the depth of the ram stroke. Because of the impact nature of the encounter between the ram and such panel, a whip action often accompanies this procedure, causing a dangerous and undersirable condition.

Among the objects of my invention are;

1. To provide a novel and improved ram type machine;

2. To provide a novel and improved ram type machine in which the movement of the ram is capable of being altered during a work stroke to meet various work conditions;

3. To provide a novel and improved press brake;

4. To provide a novel and improved press brake which operates efficiently to perform air bending operations with extreme accuracy, while eliminating dangerous work-piece whip;

5. To provide a novel and improved press brake machine wherein the rate of advance of the ram while in engagement with the work may be reduced to assure extreme accuracy in air bending, and at the same time avoid probable whipping of the work piece when such work piece extends a substantial distance to the front of the forming die;

6. To provide a novel and improved press brake machine with a power takeoff, which enables the hydraulic system for the press brake to provide a source of hydraulic drive power for operating auxiliary equipment wherein such hydraulic power is available to handle a wide variety of loads and at selected speeds.

Additional objects of my invention will be brought out in the following description of a preferred embodiment of the same as applied to a press brake machine, taken in conjunction with the accompanying drawings, wherein;

FIG. 1 is a schematic view depicting the invention as applied to a press brake machine, in a condition of rapid advance of the ram;

FIG. 2 is a basic circuit diagram associated with the machine of FIG. 1 and depicting the state of the circuitry with the machine in the condition depicted in FIG. 1;

FIG. 3 is a view corresponding to that of FIG. 1 but depicting the machine in the connection prevailing when operating at normal press speed, which is the basic speed of the press at full rated tonnage (about 60 inches per minute);

FIG. 4 is a view corresponding to that of FIG. 2, but depicting the circuitry representative of the operating condition of the machine as depicted in FIG. 3;

FIG. 5 is a view corresponding to FIG. 1, but depicting the machine in the condition prevailing when operating at anti-whip speed, which is the slow speed portion of the working stroke of the press;

FIG. 6 is a view corresponding to that of FIG. 2, but depicting the circuitry corresponding to the condition of the machine depicted in FIG. 5;

FIG. 7 is a view corresponding to FIG. 1, but depicting the situation prevailing following a work stroke and with the hydraulic system adjusted for a return stroke of the ram;

FIG. 8 is a view corresponding to that of FIG. 2, but depicting the circuitry representative of the situation prevailing in the machine of FIG. 7;

FIG. 9 is a view in section through a valve assembly constituting an important feature of the present invention;

FIG. 10 is an enlarged view of the cam operated switches and accompanying adjustment mechanism for determining stroke characteristics;

FIG. 11 is a view of the mechanism of FIG. 10 taken along the line 11—11; and

FIG. 12 is a view of a portion of the mechanism of FIG. 10, taken along the line 12—12.

Referring to the drawings for details of the invention in its preferred form, the invention has been illustrated as applied to a press brake machine embodying a ram **1** driven by a pair of hydraulic motors **3** and **5**, each involving a cylinder **7**, **9** respectively, including pistons **10**, **11** respectively. Each piston has a piston rod **13** extending from the cylinder for connection to one end of the ram.

The hydraulic motors are hydraulically connected in series by a flow connection **15** to the upper side of the one piston **10**, a flow connection **17** from the underside of said piston to the upper side of the remaining piston **11**, and a flow connection **19** from the underside of the piston **11**.

Hydraulic power is derived from a motor driven pump **21** having a suction line **23** to tank **25**, and a discharge line **27** for delivering hydraulic fluid to the hydraulic motors.

When so connected in series, the first piston **10** becomes the master piston, while the other piston **11** becomes the slave piston. Conventionally, the under side of the master piston has an area equal to the upper side of the slave piston, to assure equal rate of travel of both ends of the ram, all other factors being equal.

The stroke of the ram **1** is defined by an upper limit, a lower limit, and two intermediate positions at which the rate of travel of the ram changes. The manner in which the upper limit, lower limit and intermediate speed shift positions are determined for a particular stroke will now be described with particular reference to FIGS. **10**, **11** and **12**. A switch housing **29** is secured to a portion of the machine side housing **31** and thereby locates a depth limit switch **33**, a rapid/normal switch **35**, an anti-whip switch **37**, and a back travel switch **39**, contained therein, in fixed positions relative to the movable ram **1**. The operative members of the switches located in housing **29** are exposed for engagement with various switch operating cams carried by the ram **1** which engage the various switches at preselected positions in the stroke of the ram, and thus determine the upper and lower limits of the stroke as well as the speed of the ram at preselected portions of the stroke.

A pair of vertically spaced mounting brackets **41** are affixed to the back of the ram **1** adjacent a side edge thereof, and support a vertically oriented limit switch arm 43. A depth stop bracket 45 is slidably mounted on the limit switch arm 43 for positioning at a desired location along the arm. Operation of a threaded knob 46 secures the bracket 45 in a desired location on arm 43 by drawing a locking slide 47 into engagement with the arm 43 through a threaded connection between the knob 46 and the locking slide 47. A scale 49 mounted between the brackets 41 gives a visual indication of the depth selected, while a micrometer 51, the end of which operates the depth limit switch 33, provides means for an extremely fine determination of the lower limit of travel of the ram 1.

The upper limit of the ram is determined by the position of a back travel bracket 53 which is slidably mounted on the arm 43 and secured at a selected position thereon by operation of an adjustment knob 55 which operates a locking mechanism [not shown] similar to that described above in connection with bracket 45. The particular position of back travel bracket 53 on arm 43 determines the height of the ram 1 when bracket 53 engages the operating roller of back travel switch 39 which when operated, establishes the necessary electrical and hydraulic conditions for stopping the upward travel of the ram, as will be described in greater detail below.

The position along the ram stroke at which the speed of the ram shifts from rapid to normal speed is determined by the engagement of a cam 57 with the roller of the rapid/normal switch 35. Such position of engagement may be varied by selection of the distance which the cam 57 depends below the bracket 45. For this purpose, cam 57 is slidably mounted in bracket 45 and locked in a selected position by operating an adjustment knob 61 which is threadably engaged to a locking slide 63 installed in the bracket 45 and which when drawn toward the knob 61, binds a contoured portion against the cam 57, securing it to the bracket 45.

The slide 63 is formed with an additional contour through which a second cam 59 extends, this contour being sufficiently large, such that no binding between the slide 63 and cam 59 is possible, thus leaving the cam 59 free to pass through the slide 63 at all times.

This second cam 59, which may be termed an anti-whip cam, because of one of its functions in the system, is adjustable in precisely the same manner as described with reference to cam 57, by operation of an adjustment knob 65, which operates a locking slide [not shown] similar to slide 63, but in this case with the oversized contour adjacent the cam 57, to allow the anti-whip cam 59 to be locked into place without interfering with the rapid/normal cam 57.

The cams 57 and 59 pass through a pair of cam guides 67 secured to the arm 43. The cams are locked to the guides by set screws 69, and hold the cams in the proper position for engaging their respective switches at the preselected points in the work stroke, to insure proper operation of the system at the desired locations.

The manner in which the operation of the various switches results in change in the operation of the ram will be described herein below.

In accordance with the present invention, the flow-connection from the underside of the slave piston 11 is selectively connectable either to the tank 25 or to the discharge line 27 of the pump, and this, in the specific embodiment of the invention illustrated, is accomplished through the intermediary of a normally open rapid/normal valve 70 which is controlled by normally open pilot valve 71 energizable by a solenoid 73. With valve 70 open, flow is provided directly to the tank 25, to provide normal speed to the ram on its down stroke.

On the other hand, with the valve 70 closed, the pump fluid supplied to the upper side of the master piston, will be supplemented by the fluid from the underside of the slave piston, the combined effect of which will be to drive the ram at a relatively high or greater than normal rate of movement.

As will be more fully described below, the ram will change from such relatively high rate of movement to normal speed in an air bending operation, the change preferably occuring when the work piece is initially engaged by the ram. In order to more accurately terminate the work stroke at a predetermined location and at the same time eliminate the potentially dangerous whip action, when the work extends substantially beyond the die, the present invention provides means by which the ram operates at a yet slower speed for the terminal portion of its work stroke, which may be for as little as ⅛ of an inch, or as much as 1–½ inches depending on the probability of whipping of the work occuring.

This mode of operation is accomplished in the present invention through the intermediary of a normally open valve 74 controlled by a pilot valve 75 which is operated by a solenoid 77 and which is hydraulically situated between the pump 21 and tank 25. In the connection to the valve 74 is a restrictive orifice 79 of a size to limit the flow through this valve to a valve which will reduce the ram speed to a desired slow rate which will permit accurate termination of the work stroke in air bending and at the same time, prevent whipping of the work, should it extend some distance to the front of the forming die.

Connecting the discharge side of the pump to tank, by a connection 87 is a modified relief valve assembly. Such assembly conventially includes a normally open valve 82 to tank, which valve is controlled by a normally open pilot valve 83 energizable by a solenoid 85.

During operation of the press, solenoid 85 is energized to close the pilot valve 83 which in turn causes closure of relief valve 82. In this condition, the relief valve is adapted to respond to pressure in excess of rated load to protect the machine, the relief pressure setting being determined by a spring loaded check valve 86 associated with the pilot valve.

In its normally open condition, it represents idling of the machine. Under these conditions, the ram is supported in its up position, by installing a spring loaded check valve 88 in association with the pilot valve 71 to preclude opening of the pilot valve until hydraulic pressure exceeds that necessary to support the ram.

To provide for initiating a down or work stroke of the ram, a normally closed valve 90 is installed in the line 15 to the master cylinder. This valve is controlled by a normally closed pilot valve 91, energizable by a solenoid 93, which when energized, results in opening of valve 90 to supply hydraulic power for a work stroke.

Upon completion of the work stroke, the solenoid 93 is de-energized to close the valve 90. Likewise, valve 70 is closed by energizing solenoid 73 to block discharge to tank at that point in the system.

To effect a return of the ram to its up position, a discharge to tank is provided from above the master piston by way of a normally open valve **94** controlled by a normally open pilot valve **95**, which is energizable by a solenoid **97**, which, when energized, opens the valve **94**. For the return stroke, the solenoid is de-energized.

In addition to the valve **94**, another valve **98** is employed, this valve being installed in the discharge line **19** from the slave piston to the pump discharge line **27**. Valve **98** is a normally closed valve controlled by a normally closed pilot valve **99**, energizable by a solenoid **101**. For a return stroke, the solenoid is energized.

In FIGS. **2**, **4**, **6** and **8** is depicted the circuitry involved in controlling the machine of FIGS. **1**, **3**, **5** and **7**, each circuit corresponding to the status of the valve assemblies in the figure appearing above it.

Referring to FIG. **2** for a description of the pertinent circuitry, the control of the machine is centered in a foot switch **103** adapted to be shifted to an up position, where it spans an upper pair of contacts **105** from a lower position where it spans a pair of contacts **107**, corresponding contacts on one side of the switch being connected to one side **108** of power lines **108** and **110**, which are electrically energized by a transformer **112**.

The solenoid **85** which operates the pilot valve **83** is connected between the contacts **105** and the line **110** through a pair of normally closed contacts **109**, while the solenoid **93** of down valve **90** which controls the flow between discharge line **27** and master piston **10**, is similarly located between contact **105** and line **110**, but through a pair of normally closed contacts **111** and switch **112**.

Solenoid **97** which operates valve **94** is connected between lines **108** and **110** through a pair of normally closed time delay relay switch contacts **113** and series connected push button switch contacts **115**.

The solenoid **77** associated with the anti-whip valve **14** is connected between the lines **108** and **110** through normally closed anti-whip switch **37** and normally closed manual speed advance selector switch **117**.

Solenoid **73** which operates the normally open rapid/normal speed valve **70**, is connected between line **108** and line **110** through normally closed rapid/normal switch **35**, two pairs of contacts of the speed advance selector switch **117** and normally closed anti-whip switch **37**. Shunting all these switch contacts, is a pair of normally open contacts **121** which when closed, could establish a holding circuit for the solenoid **73**.

With the circuit as shown, solenoid **97** is energized to close upstroke dump valve **94**, solenoid **73** is energized to close rapid/normal valve **70**, and solenoid **77** is energized to close anti-whip valve **74** thus conditioning the circuit for a down or work stroke by energizing solenoids **93** and **85** to respectively open valve **90** and close valve **82**. This is accomplished by operating the foot switch **103** to close contacts **135** and open contacts **107**. Valve **70** being closed and valve **98** being open, the discharge from beneath the slave piston will supplement the pump supply to the master cylinder and produce a rapid advance of the ram.

As the ram moves downward, the rapid/normal switch **35** will be actuated by cam **57** which in turn will eliminate solenoid **73** from the energized circuits, causing rapid/normal valve **70** to assume its normal open condition, whereby the underside of slave piston **11** will communicate through its discharge line **19** with the tank **25**, thereby reducing the speed of the ram to the normal speed, the hydraulic circuit for which is depicted in FIG. **3** and the electrical circuit in FIG. **4**.

As the ram continues further at normal speed, the anti-whip switch **37** will be engaged by cam **59**, thereby de-energizing the solenoid **77** of anti-whip valve **74** whereby the valve will assume its normally open condition and permit flow of fluid from discharge line **27** through restrictive orifice **79** to tank **25**, and thus produce the slow speed operation of the ram, the hydraulic and electrical circuits determining such operation being depicted in FIGS. **5** and **6** respectively.

The end of the ram stroke is defined by the position at which the depth limit switch **33** is engaged by the micrometer **51**, which results in the opening of the upper contacts **33A** of the limit switch **33** and the closing of its lower contact **33B**, providing a temporary electrical path from line **108** through contacts **105**, contacts **33B**, the contacts of a mode selector switch **123**, back travel limit switch **39**, and time delay relay **125** which includes fast acting normally closed relay contacts **109** and **111** and normally open relay contacts **127**, in addition to slow acting contacts **129**.

Opening of contacts **109** and **111** de-energizes solenoid **85** to open relief valve **82**, and de-energizes solenoid **93** to close valve **90**. Thus power is removed from the machine by valve **82** and the hydraulic circuit is broken by valve **90**.

The closing of contacts **127** serves to establish a holding circuit for relay **125**, to maintain the same electrical conditions after the depth limit switch **33** returns to its normal condition upon subsequent starting of the return stroke.

After a brief delay, time delay relay contacts **129**, which are normally open, now close to provide energization to an up stroke relay **131** which operates normally open contacts **121**, **133**, **134** and **135** and normally closed contacts **113** in the circuit. Closing of contacts **133**, **121**, **134** and **135** causes the solenoids **101**, **73**, **77** and **85** to be energized. These in turn operate associated up valve **98**, normal speed valve **70**, anti-whip **74** and relief valve **82** respectively, to establish the hydraulic circuit of FIG. **7**, resulting in the up stroke mode of operation of the ram, which continues until the bracket **53** engages the back travel limit switch **39**, which, when engaged, opens and removes the time delay relay **125** and the up stroke relay **131** from the circuit, thus restoring their associated contacts to their normal condition, whereby the appropriate conditions are re-established for a new cycle starting a work stroke with an initial rapid advance of the ram.

The speed advance selector switch **117** provides an override to the normal automatic speed cycle of the machine as described above, where it is desired to eliminate either the initial rapid advance speed or both the initial rapid advance speed and the normal speed, such as where the operator is using the machine to form a single piece and is eyeing the ram to the work piece, under which circumstances, the slowest possible operation of the machine is desired.

By manually selecting the middle contacts of the selector switch **117** in preference to the upper contacts, the rapid/normal switch **35** is effectively removed from the circuit, as if operated by its associated cam, whereby the machine operates in the normal speed range.

If the lower contacts are manually selected, both the rapid/normal switch and the anit-whip switch **37** are effectively removed from the circuit as if operated by their associated cams, whereby the machine operates in the slow of anti-whip speed for the entire stroke.

In the operation of a press brake it is important to maintain careful control over the maximum force applied by the ram during its work stroke to avoid excessive forces which could result in damage to the machine itself. The relief valve assembly **81** is provided to prevent the pump **21** from providing greater fluid pressure to the system than that for which the machine is rated, and it is thus required that the setting of the relief valve be periodically checked to assure that it is maintaining the desired maximum pressure and allowing none greater.

The normal procedure for effectuating this check is to block the ram to cause the ram to exert its maximum force and then measure and adjust the pressure at which the relief valve operates. In the present invention, the novel arrangement of valves in the hydraulic circuit together with the correct conditioning of the electrical circuit allows for this pressure check, sometimes termed "tonnage control," to be carried out without blocking the ram and accordingly with great savings in time and without possible damage to the machine.

Toward this end a manually operated switch **137** is provided, which includes a pair of normally closed contacts **115** in circuit with solenoid **97**, a pair of normally open contacts **139** in parallel with normally open up stroke relay contacts **134**, a pair of normally closed contacts **112** in circuit with solenoid **93** and a pair of normally open contacts **144** bridging normally open up relay contacts **135**.

When the manually operated switch **137** is operated, the solenoid **97** is de-energized whereby up stroke drive valve **94** assumes its normally open condition, solenoid **85** becomes energized to close relief valve **82**, and solenoid **93** is taken out of its active circuit, enabling down valve **90** to assume its normally closed condition. With up valve **98** in its normally closed condition, and down valve in its normally closed condition, the discharge line of the pump **21** is unable to deliver fluid to either of the pistons **10** and **11**, and with solenoid **77** operating anti-whip valve to its closed condition, all of the output from the pump goes to the relief valve assembly where the pressure will build up until the relief valve opens (in a manner to be described in detail herein below). A pressure gage **145** can be advantageously connected to the relief valve to measure the pressure developed therein for purposes of tonnage control and adjustments in the valve made until the desired maximum pressure is achieved.

The conditions set forth above by which all of the pump fluid is directed to the bypass line **87** leading to the relief valve assembly **81**, establishes ideal conditions for providing hydraulic power for an auxiliary machine, as the present invention provides the ability to furnish such power over a relatively broad range of flow rates and pressures. A takeoff line **147** from line **15** downstream of relief valve assembly **81** leads to a normally closed valve **148** controlled by a pilot valve **149** operated by a solenoid **151** which is all that is required for an advantageous power takeoff from the machine of the present invention, after it is conditioned to the mode produced by operating the manually operated multi-contact switch **137**.

By selective operation of the anti-whip valve **74** with a variable setting on the restrictive orifice **79**, together with adjustable relief valve setting (as described herein below) the flow rate and pressure of the fluid provided to the power takeoff conduit **147** is capable of meeting a wide variety of demands, depending on the machine to be operated.

Referring now particularly to FIG. **9**, where the relief valve assembly **81** is depicted structurally, such relief valve assembly may include a valve housing **155** having an offset main flow passageway therethrough, the input end **157** for flow connection to the pump discharge line **27**, while the discharge end **159** is connected to a tank **25**. At an intermediate point in the main flow passageway, is a valve seat **161** against which a spool shaped main valve **163**, which corresponds to the valve element in valve **82** of FIGS. **1**, **3**, **5** and **7**, is normally seated by a biasing spring **165**, housed in a recess **167** in the valve and bearing against a head section **169** to create a small chamber **171**, adjacent the end of the valve. A small opening **173** through the upper end of the spool shaped valve **163**, permits liquid communication between the inlet **157** of the main passageway and the small chamber **171**, whereby hydraulic pressure may accumulate in the spring recess and the small chamber above to assist the spring in maintaining closing pressure on the main valve.

An auxiliary passageway **177** from the input end of the main flow passageway to the opposite end of the spool shaped main valve, will bring pump pressure to bear against the lower end of the valve in opposition to the pressure built up in the spring recess due to the combined liquid pressure and that of the main valve biasing spring. The normal differential pressure will be in the direction of seating the main valve. Any release of the hydraulic pressure assisting the spring, will reverse the differential pressure on the main valve, which will then be in the direction of opening such valve.

Slidably mounted on the head section is the solenoid actuated pilot valve **83**. Release of hydraulic pressure from the chamber **171** is normally provided by this pilot valve, which is adapted to open or close a by-pass passageway **181** about the main valve, such by-pass passageway including the opening **173**, chamber **171**, the pilot valve **83**, and a return passageway **182** in the main valve housing **155**, which terminates at the discharge end **159** of the main valve passageway. A pressure responsive valve assembly **183** located in the head section, include portions of this by-pass passageway through the pilot valve and provides means for circumventing the pilot valve when the pilot valve is closed and pressure in the hydraulic system exceeds a predetermined maximum safe pressure for operation of the machine.

Such pressure responsive valve assembly includes a valve seat **191** installed at one end of a bore **192** with its exposed end recessed to receive the end of a conical valve **193** which is normally biased to its blocking position by a biasing spring **195**. The seat **191** has an intermediate reduced portion disposed between a section **197** of the by-pass passageway **181** which section communicates directly with chamber **171**, and another section **199** which registers with that portion of the passageway through the valve **83** when the valve is in its open position.

A diametrical passage **201** through the seat **191** in the region of the reduced section communicates with a longitudinal passage exiting at the center of the seat to provide a passageway circumventing the pilot valve, and which is controlled by valve **193** in opposition to the spring **195**.

The pressure at which spring **195** is effectively counteracted depends on the location within the bore of a spring seat **203**, the longitudinal position of which is adjustable through the intermediary of a threaded bolt **205**, the end of which abuts the spring seat **203**, such adjustability permitting the setting of the relief valve assembly for excessive overload. When the spring is adjusted to a desired overload relief pressure, a locking nut **207** fixes the adjustment against accidental departure from such setting.

In response to opening of the valve **193**, the main relief valve will remove power from the machine by connecting the pump discharge to tank. This ability to adjust the pressure setting of the relief valve, when taken in conjunction with the control switch **137** and its function in blocking flow in all lines except line **87** to the relief valve assembly, constitutes the tonnage control feature of the present invention. No longer is it necessary to bring the ram down against a load and adjust the relief valve as the load is increased to its maximum permissible value.

This tonnage control feature may be enlarged upon to permit adjustment of the output of the machine to work which might otherwise be adversely affected, if the power output of the machine were not reduced from its rated load, such adjustments being available without disturbing the initial or rated load adjustment for the machine.

With this in mind, a tonnage control valve assembly **211** substantially identical to valve assembly **183** in construction is provided, which includes a spring loaded check valve **184** similar to valve **86** and operates in exactly the same manner as described above with respect to valve **86**. This tonnage control valve, however, includes a more readily adjustable valve spring **213**, by adding to the adjusting bolt **212**, a threaded stud **214** passing axially therethrough to bring pressure to bear on the end of the spring seat **215**, such stud being adjustable as by means of a screw driver, without requiring the use of a locking nut. When the hydraulic system is being used to operate the press brake machine at rated load, the spring **213** of the tonnage control valve assembly is adjusted to exceed the pressure of the spring **195**, to effectively eliminate this tonnage control valve from its functional operation.

When it is desired to operate the press brake machine at lower than rated load, to reduce the maximum available pressure to a value less than the maximum pressure dictated by the initial adjustment of the spring **195**, the spring **213** of the tonnage control valve **184** is adjusted to provide less counter pressure than the spring **195**. By utilizing separate adjustable valve for this purpose, the adjustment of spring **195**, when once established for rated load need not be disturbed, when it is desired to utilize the machine at maximum pressure less than rated load.

From the foregoing, it will be come apparent the tonnage control valve assembly **211** can also be availed of in controlling available pressure to the power takeoff line **147**.

With a machine embodying the various features described above, not only can one realize a time saving factor in bringing the ram to the work at a greater than normal speed of the ram, but, where air bending is involved, the ram can be slowed down sufficiently as it approaches the end of its work stroke, to assure extreme accuracy, which would not otherwise be available due to the momentum which the heavy ram would otherwise have at the higher speeds.

If the nature of the work is such that whipping of the same would occur at say normal speed of the ram, the cams can be so adjusted as to eliminate the normal speed and change directly from rapid advance to the slow or anti-whip speed as the ram engages the work.

On the other hand, if the work is short or whipping is otherwise not a factor, the cams can be adjusted so that the ram can perform its work at normal speed until it approaches the end of its stroke, when for the last one-eighth inch or so of the stroke, it can be slowed down to the anti-whip speed to assure accuracy in air bending.

Aside from the forgoing, the overload relief valve can be readily adjusted without the necessity of preloading the machine; and adding to this the ability to readily provide power from the hydraulic system of the machine to drive auxiliary or ancillary equipment, one can appreciate that the invention as described, fulfills all the objects of the invention previously set forth.

While I have described the invention in its preferred form and in considerable detail, the same is subject to alteration and modification without departing from the underlying principles involved, and I accordingly do not desire to be limited in my protection to the details set forth except as may be necessitated by the appended claims.

I claim:

1. A machine of the type employing a reciprocal ram to perform an operation on work, wherein there are a pair of hydraulic motors, each coupled to a different end of said ram to drive the ram, each of said hydraulic motors involving a cylinder and included reciprocal piston, a hydraulic power system including pump means and said hydraulic motors, the hydraulic system including a flow connection from the pump means to the upper side of one piston, a flow connection from the underside of said one piston to the upper side of the other piston, and a flow connection from the under side of said other piston to provide a series flow relationship of said hydraulic motors, whereby said one piston becomes the master piston and said other piston, the slave piston; means for engaging and operating on work with said ram during a work stroke, at a speed comparable to the normal speed of said ram, and means responsive to approach of said ram toward the end of its work stroke, for reducing the speed of said ram to reduce the inertia thereof and assure an accurate termination of said work stroke.

2. A machine in accordance with claim 1, characterized by means for advancing the point in said work stroke for reducing said ram speed, in the case of work subject to whipping when engaged and operated on by said ram at said normal speed.

3. A machine in accordance with claim 1, characterized by said means for reducing the speed of said ram to reduce the inertia thereof, as including means for reducing the flow rate of hydraulic fluid to the hydraulic motor of said master piston.

4. A machine in accordance with claim 3, characterized by said means for reducing the flow rate of hydraulic fluid to said hydraulic motor, as including means for diverting from said series of hydraulic motors, a portion of the hydraulic fluid discharge from said pump means.

5. A machine in accordance with claim 4, characterized by said diverting means including a valve and in series therewith, a restrictive orifice to meter the diverted flow.

6. A machine in accordance with claim 1, characterized by means for establishing a higher than normal speed of said ram during the initial portion of its work stroke, and means for converting said higher than normal speed to substantially normal speed as said ram reaches the work to be operated on.

7. A machine in accordance with claim 6, characterized by means for adjusting the points in a work stroke where said speed changes occur.

8. A machine in accordance with claim 7, characterized by said means for adjusting the points in a work stroke where said speed changes occur, as including cam operated switch means for each speed change, on a portion of said machine adjacent to and stationary relative to said ram, switch activating cam means on said ram for engaging each of said switch means during a work stroke of said ram, speed change control circuits including said cam operated switch means, and means for adjusting said switch actuating cam means to alter the points of speed change in said work stroke.

9. A machine of the type employing a reciprocal ram to perform an operation on work, wherein a pair of hydraulic motors, each coupled to a different end of the ram, drive the ram, each of said hydraulic motors involving a cylinder and included reciprocal piston, a hydraulic power system including pump means in power supply relationship to said hydraulic motors, relief valve means for the machine connected in said hydraulic system on the discharge side of said pump means, in bypass relationship to said hydraulic motors, said relief valve means being closed during normal operation of said machine and including spring adjustment means for establishing relief pressure setting of said relief valve means, and means for enabling the setting of said relief valve means to a predetermined relief pressure without first loading the hydraulic motors of said machine, said enabling means including a pressure gauge, pressure coupled to the pressure side of said relief valve means, and means for blocking hydraulic fluid flow to said hydraulic motors downstream of said relief valve means connection, to permit adjustment of said spring adjustment means under guidance of said pressure gauge.

10. A machine in accordance with claim 9, characterized by said hydraulic system including said hydraulic motors in series.

11. A machine in accordance with claim 9, characterized by a hydraulic power take-off connection from said hydraulic system, and means for blocking power to said hydraulic motors during use of said power take-off connection.

12. A machine in accordance with claim 11, characterized by means for utilizing said relief valve means to protect against overload, apparatus operating off of said power take-off connection, said means including connecting said power take-off connection from a location in said hydraulic system in pressure communication with said relief valve means while power to said hydraulic motors is blocked off.

13. A machine in accordance with claim 12, characterized by means for adjusting the setting of said relief valve means to the load limitations of the apparatus to be operated off the power take-off connection and without disturbing the relief pressure setting for the machine.

14. A machine in accordance with claim 13, characterized by said adjusting means including a second spring adjustment means in said relief valve means, disposed in parallel relationship to the first spring adjustment means, said second spring adjustment means including means for adjusting to pressure values both above and below the relief pressure setting for said machine.

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