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[54] **HYDRAULIC ACTUATING SYSTEM FOR HYDRAULICALLY OPERATED BENDING MACHINE**

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[51] **Int. Cl.** **F15b 11/08**, F15b 13/042

[58] **Field of Search** 91/436, 437

[56] **References Cited**

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[57] **ABSTRACT**

A hydraulic actuating system for a hydraulically operated bending machine which is so designed and constructed that, by using an automatically operable pressure-sensitive valve, the hydraulic ram and driving apron is caused to move at an increased speed during its idle movement towards the workpiece by bypassing fluid from the discharge chamber of the ram to the drive chamber and at a decreased speed but increased force during the bending operation by passing fluid from the discharge chamber to the tank.

2 Claims, 3 Drawing Figures

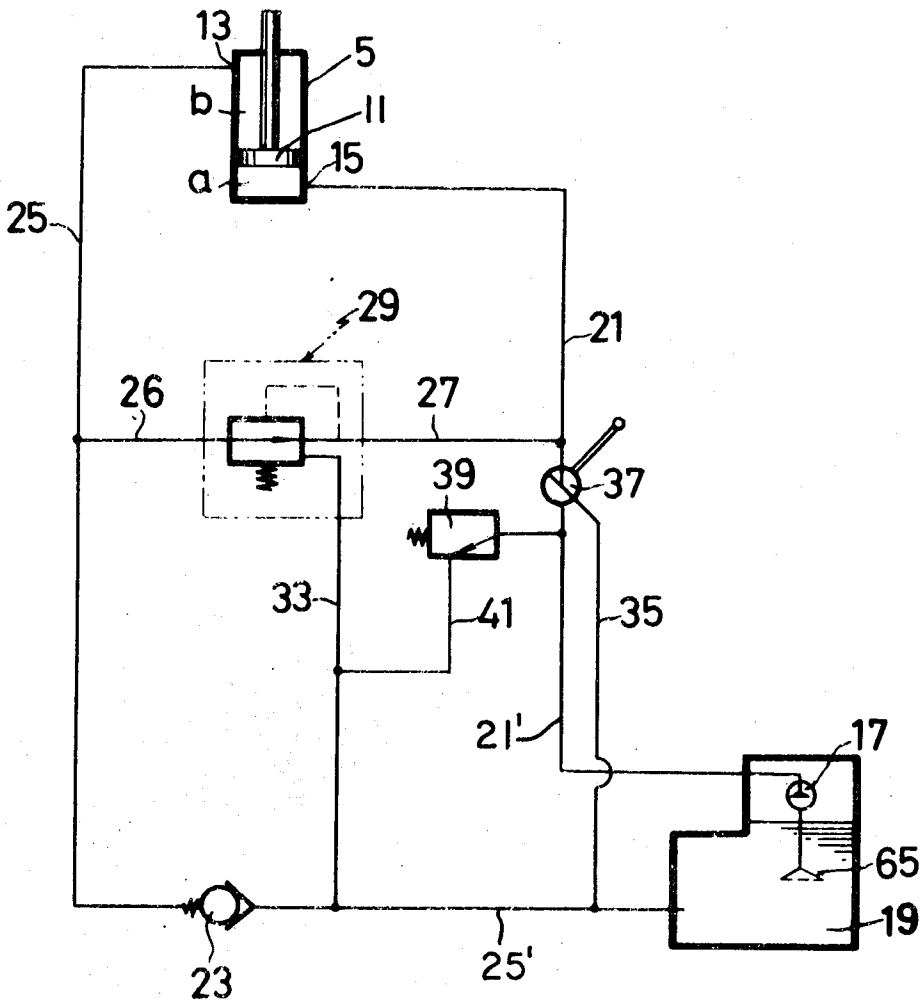

FIG. 1

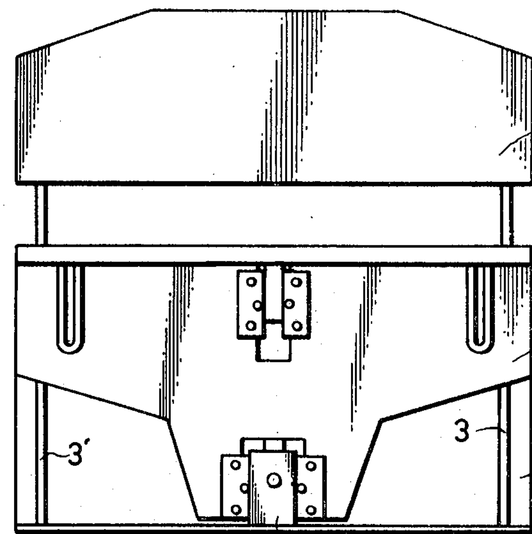

FIG. 3

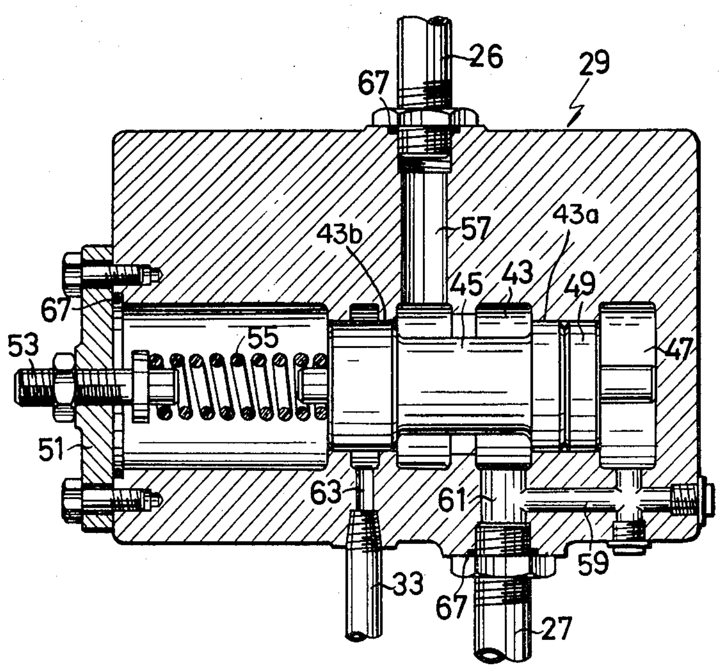

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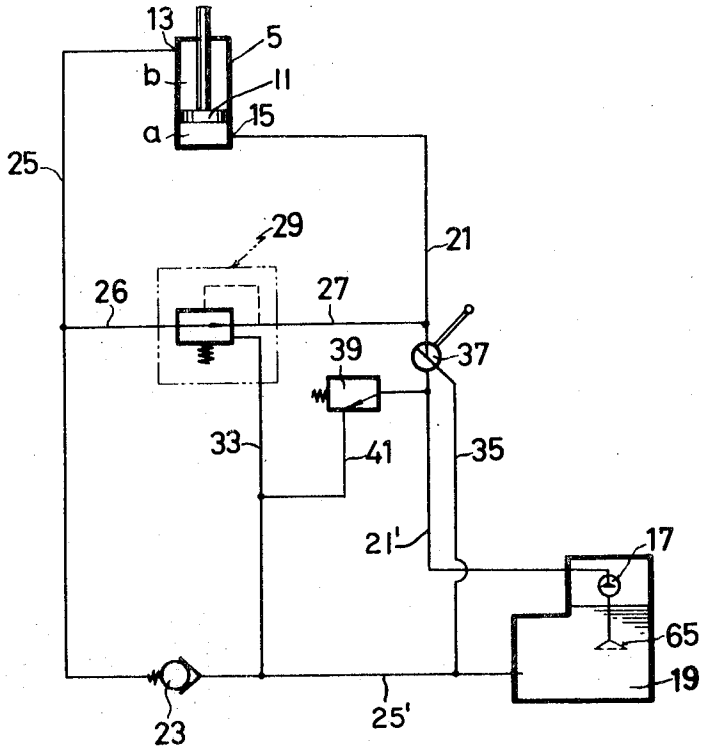
FIG. 2



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HYDRAULIC ACTUATING SYSTEM FOR HYDRAULICALLY OPERATED BENDING MACHINE

DESCRIPTION OF THE INVENTION

The known conventional hydraulic bending machines are usually provided with a hydraulic ram having variable strokes and the capability of being brought to a halt during its advancing movement. However, the speed of the upward idle movement of the hydraulic ram for such bending machines can not be increased considerably as in the case of mechanically operated systems, thus resulting in a lowered operating efficiency. Various complicated systems have been attempted to obviate this drawback. For example, a plurality of hydraulic rams have been employed in a particular operation in order to achieve different operating speeds for the hydraulic ram. Alternatively, hydraulic pumps with a lower output and a higher pressure or conversely with a higher output and a lower pressure has been utilized selectively for the particular operation. Still alternatively, a plurality of hydraulic cylinders have been provided in conjunction with the hydraulic ram so that the single cylinder situtated in the position of gravity is actuated for attaining a higher ram speed and the cylinders are actuated as a whole for feeding the ram at a decreased speed in the course of the bending operation. These known devices are complicated in their construction and highly costly, especially for small sized machines and therefore disadvantageous economically as contrasted to the mechanically operated machines.

According to the present invention, there is provided a hydraulically operated bending machine with one operating cylinder and simplified construction including a hydraulic circuit in which the upward stroke of the hydraulic ram from its starting position to the position of abutment with the work for deforming the same is attainable within a short period of time, and the maximum force developed by the hydraulic pump is fully utilized for deforming the work in the course of the bending operation, and the energy of a single motor of small capacity is used most effectively for the entire operation.

Other objects, features and advantages of this invention will become more apparent by referring to the accompanying drawings and the detailed disclosure which follows.

DRAWINGS

FIG. 1 is a front view of a bending press in which the hydraulic ram is actuated by a hydraulic circuit embodying the concepts of the present invention;

FIG. 2 is a schematic diagram showing the inventive hydraulic circuit;

FIG. 3 is an enlarged sectional view of a sequence valve.

As shown in FIG. 1, the bending press has a base 1 and a pair of guide tracks 3,3' secured to the left-hand and right-hand sides of the base 1. A lower movable apron or ram 7 is slidably mounted on tracks 3,3' and driven by a driving hydraulic cylinder 5. An upper fixed apron 9 is secured to the upper ends of the tracks 3,3'. Referring now to the hydraulic circuit for driving the lower movable apron 7, there is provided a piston 11 slidably received inside the driving hydraulic cylinder 5, the latter having an upper port 13 and a lower port 15. The lower port 15 is connected to a hydraulic conduit 21,21' through which hydraulic fluid is conveyed from a tank 19 by means of a hydraulic pump 17. The upper oil port 13 is connected to another conduit 25,25' which includes a check valve 23 and which is also connected to the tank 19. A sequence valve assembly 29 is provided as shown. Assembly 29 is connected to conduits 25 and 21 by means of intermediate conduits 26 and 27. A further conduit 33 is provided between valve assembly 29 and conduit 25'. In the conduit 21', there is provided a three-way valve 37 adapted for switching to a conduit 35 and returning the fluid supplied under pressure back into tank 19. A relief valve 39 is inserted in a conduit 41 connecting conduit 21' to conduit 33.

Referring now to FIG. 3, the sequence valve assembly shown generally at 29 is formed with a spool chamber 43 having reduced diameter sections 43*a* and 43*b* and receiving slidably therein a spool-like member 45, and a cylindrica' chamber 47 communicating with the reduced diameter section of the spool chamber 43. The spool-like member 45 is formed, at its right-hand end as viewed in FIG. 3, with a piston 49 which is slidably received in the reduced diameter portion 43a of the spool chamber 43 and which is formed with a circular oil groove. A spring 55 is mounted under compression between the other end of the spool 45 and a spring retainer 53 adjustably mounted to a cover 51 over the enlarged opening at the other end of the spool chamber 43. The valve assembly has an oil port 57 which is hydraulically connected with the spool chamber 43 and with conduit 25 via conduit 26, and a further port 61, the latter being formed with a pilot duct 59 communicating with the cylindrical chamber 47 and being hydraulically connected with conduit 21 via conduit 27. The valve assembly also has a further port 63 connected to conduit 33 and adapted for hydraulic connection with the spool chamber 43 when the spool 45 is urged to move leftwards in the drawing. Numeral 65 in FIG. 2 denotes a suction element and numeral 67 in FIG. 3 denotes a packing.

The present device operates as follows: First, the three-way valve 37 is manipulated so as to interrupt conduit 35 and provide a hydraulic communication between conduit 21,21' and the hydraulic pump 17. At this time, the hydraulic pump 17 is made to communicate with both chambers *a* and *b* of the hydraulic driving cylinder 5 and hydraulic fluid in the circuit acts on both sides of the piston 11. However, since the lower side of the piston 11 is larger in area than the upper side of the same by the cross-sectional area of the piston rod, the pressure acting on the underside is greater and the piston is moved upwardly. Therefor, pressurized hydraulic fluid is supplied from the hydraulic pump 17 into the driving chamber *a* of the hydraulic driving cylinder 5 for urging the piston 11 and thereby the lower movable apron 7 to move upwards. Hydraulic fluid discharging from chamber *b* of the driving cylinder 5 flows through conduit 25 via port 13 as said piston 11 is elevated in its position. The fluid thus discharged into conduit 25,25' is checked by the check valve 23 from returning into the tank 19 and is forced into spool chamber 43 of valve assembly 29 via conduit 26 and flows through conduit 27 to be united with the fluid delivered through conduit 21,21'. Thus, the fluid from the pump and the discharging chamber of the hydrualic cylinder is supplied together into the driving chamber *a* of the

hydraulic driving cylinder 5 and acts on the lower end of the piston 11. In this way, the hydraulic fluid is supplied into the driving chamber *a* in an amount equal to the output of the hydraulic pump 17 added to the fluid already supplied into the discharging chamber *b* of the driving cylinder 5. As a consequence, piston 11 is moved upwards at an increased speed, and the lower movable apron 7 is brought near to the workpiece (not shown) equally at an increased speed and in a shorter period of time. When the workpiece is contacted between the upper apron 9 and the lower movable apron 7, the pressure prevailing in the driving chamber *a* of the hydraulic driving cylinder 5 is elevated as a result of the bending operation. When the pressure exceeds a certain predetermined value, the hydraulic fluid is conveyed into port 61 of the valve assembly 29 by way of conduit 27. Fluid thus conveyed into port 61 is delivered therefrom into cylindrical chamber 47 by way of pilot duct 59, resulting in the leftward sliding of the piston 49 and the spool-like member 45 against the action of the spring 55 and establishing a hydraulic communication between said spool chamber 43 and the port 63. When the hydraulic communication is established in this way between the spool chamber 43 and the oil port 63, the fluid accumulated in the discharging chamber *b* of the hydraulic driving cylinder 5 is returned to the tank 19 through conduit 33. The chamber *b* on the discharge side of the hydraulic driving cylinder 5 is thus opened to atmospheric pressure and the fluid accumulated on the side of the discharging chamber *b* of the hydraulic driving cylinder 5 is no longer united with the fluid delivered through conduit 21,21' but instead is freely returned to the tank. Thus, the hydraulic fluid on the side of the discharge chamber *b* of cylinder 5, being opened to atmospheric pressure, does not prevent the piston 11 from being raised any longer and the hydraulic pressure developed by the pump 17 acts fully on the lower surface of the piston 11. In this way, the piston 11 is moved at a decreased speed and at an increased effective pressure and therefor the lower apron 7 acts on the workpiece at a correspondingly reduced speed and an enhanced pressure. Upon completion of the bending operation, the three-way valve 37 is manipulated for closing the conduit 21' and establishing a hydraulic communication between conduit 21 and conduit 35. The driving chamber *a* of the hydraulic driving cylinder 5 is thus opened to atmospheric pressure and the piston 11 is lowered as a result of the weight of the lower movable apron 7, the pressure oil delivered to and accumulated in the driving chamber *a* of the hydraulic driving cylinder 5 being then returned to the tank 19. At this time, there is caused a negative pressure in the discharging chamber b of the cylinder 5 and the hydraulic fluid is thus delivered under suction effect caused by the weight of the lower apron 7 into said chamber *b* from the tank 19 through conduit 25,25' and check valve 23. Thus, no additional energy is required for supplying hydraulic fluid into the discharge chamber *b* in preparation for the next bending operation and therefore a pump motor of small capacity does well for the whole operation. Excess fluid delivered in this way from the pump 17 is circulated through relief valve 39 and returned to the tank 19. A flow adjusting valve means, not shown, may be provided in the conduit 35 for regulating the speed of the downward movement of the lower apron.

As above described, the device according to the present invention is designed and constructed so that the chamber of the hydraulic driving cylinder for driving the movable lower apron is divided by a piston into two chambers, i.e., drive and discharge chambers each having port means for pressure liquid and that when pressure liquid is delivered into the two chambers chamber from a hydraulic pump, the hydraulic pressure in the diacharge chamber containing the piston rod and therefore having a smaller piston area is overcome by the pressure in the drive chamber containing no piston rod and accordingly, having a larger piston area, and the pressure liquid in the discharge chamber is discharged and delivered into the drive chamber through duct means for enhancing the speed of the upward movement of the movable lower apron, and that when the latter encounters a suddenly enhanced resistance as a result of start of the bending operation, the pressure liquid from the side of said other chamber is returned to the tank by operation of an automatic valving means provided halfway in said conduit means. Especially, since the hydraulic fluid is supplied into the discharging chamber *b* of the hydraulic cylinder 5 under the suction effect caused by the weight of the lower apron 7, no additional energy is required for supplying the hydraulic fluid into said discharging chamber *b*. In such way, the energy from a single motor of small capacity is most effectively used to move the ram or lower apron at an increased speed during its idle movement towards the workpiece and at a decreased speed but with an enlarged force (or at a substantially enhanced pressure) during the bending operation. Thus, the present invention provides a hydraulic actuating system which is reasonable and safe in operation as a result of the highly simplified but effective overall construction and hydraulic piping arrangement.

It is my intention to cover all changes and modifications of the embodiment herein chosen for purposes of disclosure which do not depart from the spirit and scope of the invention as defined by the claims appended hereto.

I claim:

1. In combination, a hydraulic motor of the reciprocating type which includes a vertically extending cylinder divided interiorly by a movable piston into a drive chamber and a discharge chamber, means for controlling the operation of said motor comprising: a tank adapted to contain a supply of hydraulic fluid; a feed conduit connecting the drive chamber to a pump, the latter being operative to pump hydraulic fluid from said tank through said feed conduit into the drive chamber to cause relative movement of the piston in one direction relative to the cylinder; a bleed conduit leading from the discharge chamber to said tank; check valve means in said bleed conduit for preventing the flow of hydraulic fluid in one direction from the discharge chamber to said tank while permitting flow of hydraulic fluid in the opposite direction through said bleed conduit; self-acting control valve means connected by means of intermediate conduits to said bleed conduit, feed conduit and said tank, said self-acting control valve means being movable in response to fluid pressure in said feed conduit between a a first position establishing a connection between the discharge chamber and said feed conduit and drive chamber, and a second position establishing a connection between the discharge chamber and said tank; and, operating valve

means for interrupting the flow of hydraulic fluid from said pump to the drive chamber and for connecting the drive chamber to said tank, thereby permitting the piston to move under the influence of gravity in the opposite direction relative to said cylinder, which movement in the opposite direction will in turn create a negative pressure in the discharge chamber causing fluid to be drawn from said tank through said bleed conduit past said check valve means into the discharge chamber.

2. In combination, a hydraulic motor which includes a vertically extending cylinder divided by means of a piston into drive and discharge chambers, a piston rod extending from the piston through the discharge chamber and the cylinder end wall, means for controlling the operation of said motor comprising: a tank for containing a supply of hydraulic fluid; a pump for pumping hydraulic fluid from said tank through a feed conduit to the drive chamber; a bleed conduit leading from the discharge chamber to said tank; a check valve in said bleed conduit for preventing fluid flow from the discharge chamber back through said bleed conduit to said tank; an operating valve in said feed conduit; a by-pass conduit connected at one end to said operating valve and having its other end in communication with said tank, said operating valve being adjustable between a feed position permitting flow of fluid from said pump through said feed conduit to the drive chamber, and a by-pass position permitting flow of fluid from said pump through said by-pass conduit back to said tank while simultaneously permitting flow of fluid from the drive chamber back through said feed conduit to said tank; self-acting control valve means having a valve housing with an interior valve chamber; first, second and third ports extending through said housing in communication with said valve chamber; a first intermediate conduit connected at one end to said bleed conduit between the discharge chamber and said check valve and at the other end to said first port; a second intermediate conduit connected at one end to said second port and having its other end in communication with said tank; a third intermediate conduit connected at one end to said third port and at the other end to said feed conduit between said drive chamber and said operating valve; spool means reciprocally contained within the interior valve chamber of said control valve means; spring means for urging said spool means into a first position at which said spool means cooperates with said housing to establish a connection via said valve chamber between said first and third ports while closing off said second port, whereby when said operating valve is in said feed position, the hydraulic fluid pumped from said tank by said pump will flow through said feed conduit to the drive chamber, thereby causing movement of said piston relative to said cylinder in one direction, with the fluid exiting from the discharge chamber being caused to also flow into the drive chamber until such time as the pressure in said feed conduit is sufficient to act on said spool means to overcome the force of said spring means, at which time said spool means will be moved to a second position closing said third port and establishing a connection via said valve chamber between said first and second ports; and, whereby upon adjustment of said operating valve to said by-pass position, said piston will be caused to move under the influence of gravity in the opposite direction relative to said cylinder, thus forcing fluid from the drive chamber back through said feed conduit to said tank while simultaneously creating a negative pressure in the discharge chamber to draw fluid from said tank through said check valve and bleed conduit into the discharge chamber.

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