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RELIEF VALVE

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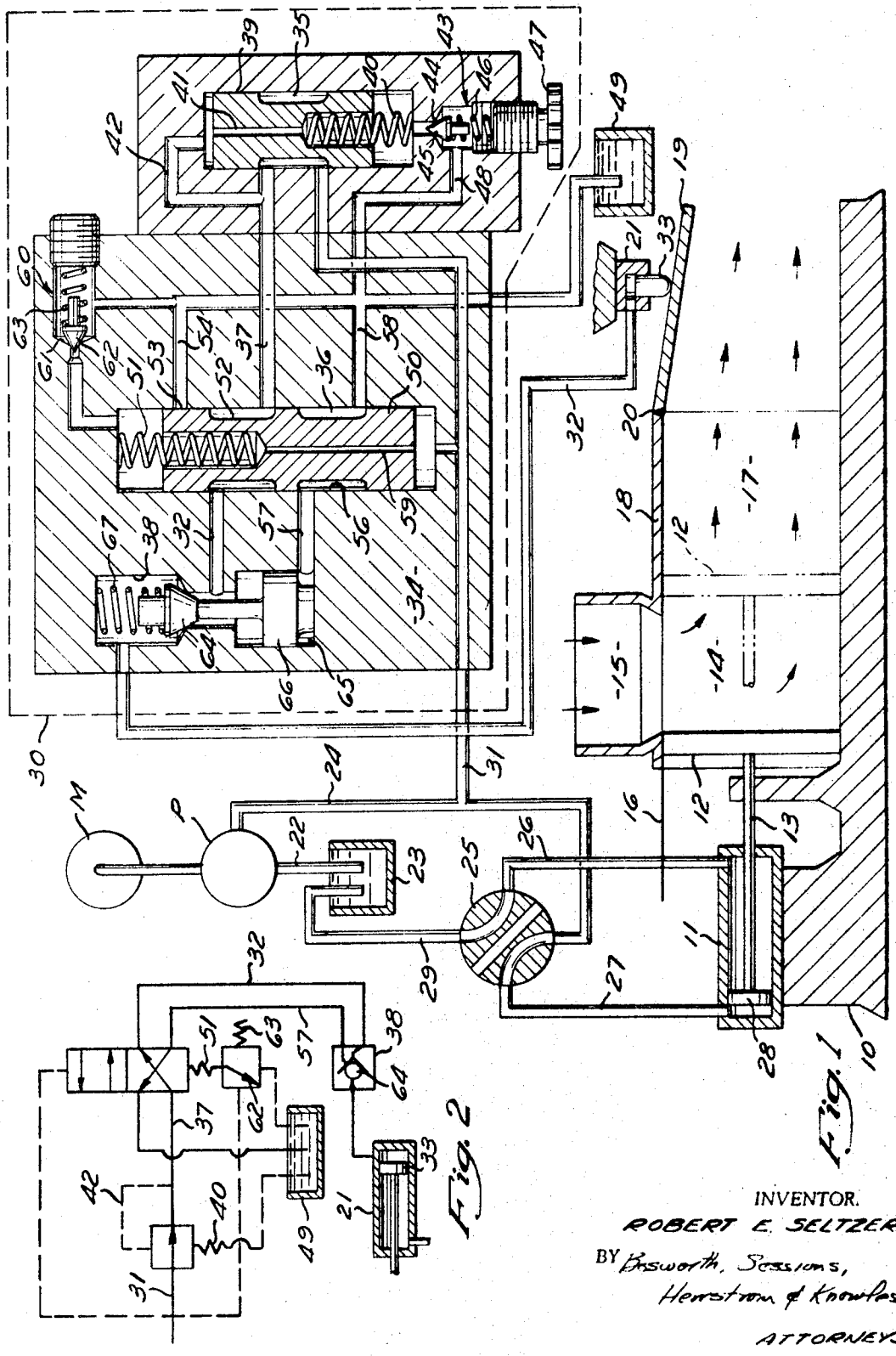

Fig. 1

Fig. 2

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RELIEF VALVE

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This invention relates to hydraulic control systems and to hydraulic valves having pressure controlling, regulating, and limiting functions.

In particular, this invention relates to an improvement in the hydraulic control device disclosed in United States Patent No. 3,179,040 granted to me Apr. 20, 1965. The invention disclosed herein is especially useful in compound closed loop systems such as, for example, hydraulic-mechanical systems in which there is a mechanical feedback path or link between two points in a hydraulic system to form a closed loop system. Typical of such systems are hydraulically operated extruding machines having a variable outlet orifice. The orifice functions as a resistance to the flow of material through the machine. The hydraulic portion of the system furnishes power, both to extrude the material and to control the orifice, and, thus, the resistance to extrusion. A hydraulically operated, continuous extrusion type of machine for baling paper or other compressible materials is a specific example of such a system and is described in some detail in my aforementioned patent. For the purpose of explanation only and not of limitation, I will describe this invention in connection with such a machine as outlined briefly below and as described more fully in my aforementioned patent.

One example of the type of baling machines I have in mind consists of a compression chamber opening into a baling chamber. A baling head driven by a hydraulically powered ram is arranged to reciprocate in the compression chamber and to compress successive amounts of material fed into the compression chamber from a feed hopper. Each stroke of the baling head compresses the material in the compression chamber against the previously compressed material and pushes it together with material compressed before into and through the baling chamber.

The baling chamber is provided with an orifice portion of minimum cross-sectional area or a throat which can be varied by hydraulic power derived from the same hydraulic system powering the compression and extrusion ram. The throat size varies the resistance to the outflow of compressed material from and through the baling chamber. As this resistance to outflow increases, the hydraulic pressure in the ram driving the positive displacement baling head must increase. If the resistance becomes too great, the machine stalls. The intended operation is interrupted, excessive heat developed and power wasted.

Such a machine, together with the material to be baled passing through the machine, represents a hydraulic-mechanical closed loop system. The baling ram and the hydraulic actuator controlling the orifice and resistance to flow through the baling chamber are interconnected on the one hand through the main hydraulic system and on the other through a mechanical path comprising the baling head, the movable orifice-defining walls of the baling chamber and the compressed material between them.

It is desirable and efficient to operate such machines near the maximum pressure that can be safely developed by the hydraulic system. Maximum pressure produces compressed or extruded bales of the greatest possible density. Efficient operation also requires that the machine not be operated into a stalled condition.

One way to prevent stalling is to use pressure relief valves in the main system. Such means are effective to

prevent stalling but greatly reduce the efficiency of the machine's operation. For example, the pressure rise in the hydraulic ram is generally hyperbolic. The very sudden and steep rise in pressure experienced just prior to stalling requires main system type relief valves to be set well below maximum deliverable system pressure if the system is to be adequately protected. This represents wasted pump capacity. Additionally, such relief valves act to dump main system pressure which must be re-established before operation can be resumed. Time and power are wasted. Because of the excessive pressure developed in the hydraulic ram is not dealt with and still must, of course, be removed or the load relieved in some manner before beginning operation again.

Another way to prevent stalling is to dump main system pressure and pressure from the orifice-controlling actuator of the machine. This is typically accomplished by an unloading valve inserted in a line branching off to tank from a line connecting the hydraulic actuator to the main system. This system also suffers from the disadvantage of permitting main system pressure and fluid to be lost to the pressure side of the system. Also, to the extent that main system fluid is lost through such an unloading valve, fluid from the hydraulic actuator is prevented from being unloaded and the problem and its solution is thereby prolonged at the expense of efficiency.

A general object of this invention, therefore, is to provide a control device for use with a hydraulically operated extrusion press having a hydraulically controllable outlet resistance or orifice and of the closed loop type described above which permits the press to be operated in a highly efficient manner and at or near full capacity without stalling and similar interruption of the machine's operation. A particular object of my invention is to provide a hydraulic anti-stall control device for such an extrusion press which prevents stalling by timely relieving of the excessive resistance load responsible for the impending stall. Another aspect of this object is to provide a device which restores the machine to its normal operating condition after relieving the excessive load.

A further aspect of the control of machines such as those described above requires means for producing bales of a uniform density while also achieving the other objects previously mentioned. The invention disclosed herein, therefore, also comprehends means for controlling the outlet orifice in accordance with a constant tensioning (or compressing) control principle to provide uniform density bales.

A general object of my invention is to provide a positive-action, reliable, trouble-free, and relatively economical improved hydraulic control device for controlling the operation of systems such as the baling machine described above and permitting all of the advantages, such as maximum pressure operation and constant bale tensioning control, while overcoming the several disadvantages noted.

These and other objects and the manner of and means for accomplishing them will be apparent from the following description and the accompanying drawings of apparatus embodying a preferred form of my invention and in which:

FIGURE 1 is a diagrammatic representation of a compound closed loop system such as referred to above and as typified by a hydraulically actuated baling machine and including, for its control, hydraulic control means comprehended by my invention;

FIGURE 2 is a schematic diagram employing conventional fluid power graphical symbols showing the hydraulic control means included in FIGURE 1.

In the lower part of FIGURE 1, a hydraulically-operated, positive-displacement type compressing and extruding machine is diagrammatically shown. Such a machine might be, for example, a paper baler.

The machine stands on a base **10** upon the left end of which is mounted a hydraulic ram **11** arranged to reciprocally operate a baling head **12** by means of piston rod **13**. The baling head **12** is arranged to move back and forth in a compression chamber **14** between substantially the solid and dotted line positions shown. Material to be compressed and extruded is loaded in hopper **15** from which it enters compression chamber **14** and is pushed and pressed rightwardly into a baling chamber **17**, as seen in the drawing, by baling head **12**. A closure **16** is provided on the side of baling head **12** adjacent the bottom of hopper **15** to prevent material in the hopper from falling into compression chamber **14** behind or to the left of baling head **12**.

That portion of baling chamber **17** adjacent compression chamber **14** is of a substantially fixed and constant cross-sectional area and, as seen in the drawing, is defined by base **10** and fixed wall **18**. A portion of the length of baling chamber **17** at the outlet end thereof is provided with at least one laterally movable wall **19** diagrammatically represented as being pivotally connected to one end to fixed wall **18** at point **20** and movable toward and away from base **10** to provide baling chamber **17** with an orifice or outlet of variable and controllable cross-sectional area. Movable wall **19** tends to be urged outwardly and away from base **10** so as to enlarge the cross-sectional area outlet of baling chamber **17** by the material pushed and pressed in and through the orifice by baling head **12**. Hydraulic actuator **21**, acting downwardly as seen in the drawing and against the outer side of movable wall **19**, tends to urge wall **19** downwardly in a direction to decrease the cross-sectional area of the outlet of baling chamber **17**. The operation of hydraulic actuator **21** will be described more fully below in connection with the hydraulic system.

The solid-line arrows superimposed on the diagrammatic compression and extrusion machine represent, by their direction, the flow of material entering hopper **15** and passing through compression chamber **14** and baling chamber **17** and, by their relative lengths, the degree of compression of the material at different points in the machine.

The hydraulic system for operating the foregoing machine comprises a pump P driven by a suitable source of power, such as motor M and having a low-pressure inlet conduit **22** entering from reservoir **23** and a high-pressure outlet conduit **24**. By means of multi-port valve **25**, high pressure from the outlet pump might be supplied selectively to either end of hydraulic ram **11** through high-pressure conduits **26** and **27**. With valve **25** in the position shown in the drawing, the pump supplies high pressure through conduits **24** and **27** to the left side of piston **28** for driving it to the right. When valve **25** is rotated 90°, high pressure is supplied from the conduit **24** to conduit **26** and enters hydraulic ram **11** on the right-hand side of piston **28**, driving it toward the left. Valve **25** has an outlet conduit **29** returning to reservoir **23**, arranged to be connected with one of the two high-pressure conduits supplying hydraulic ram **11** when the other is connected to high-pressure conduit **24**. Valve **25** may also be positioned so that fluid is merely recycled and returned to reservoir **23**, thereby permitting interruption of the operation of the machine without stopping the pump. Such a simplified system as just described for providing reciprocating motion from hydraulic pressure is, of course, well known and other different and/or more sophisticated systems may well be employed in which, for example, the multi-port valve is automatically controlled by means of limit switches or the like actuated by the hydraulic ram **11** or baling head **12**. Since this part of the hydraulic system, in and of itself, is not novel, the simplified showing made and described here is deemed adequate.

Hydraulic actuator **21**, for controlling the transverse cross-sectional area of the throat or outlet of baling chamber **17**, is connected to the main hydraulic system described above. Hydraulic actuator **21** is operated and controlled through a hydraulic control valve assembly **30** which, in all its aspects, is contained within the broken-line box in FIGURE 1 and is shown separately in conventional graphical fluid power symbols in FIGURE 2. Inlet conduit **31** of valve assembly **30** is connected to the high-pressure side of pump P through high-pressure line **24**. An outlet conduit **32** connects control assembly **30** to one side of piston **33** of hydraulic actuator **21**. Pressure supplied conduit **32** by control assembly **30** tends to urge piston **33** in a direction to reduce the cross-sectional area of the throat or outlet of baling chamber **17**. Control assembly **30** is also connected to the return side of the main hydraulic system. It will be apparent that control assembly **30** is in a position to control and to regulate the pressure in the hydraulic actuator controlling the throat or outlet resistance of the baling machine.

In one embodiment, hydraulic control assembly **30** is conveniently formed and constituted in a metal block from and of appropriately directed and connected bores and valve chambers interconnected and ported by intersection with the bores and containing operating valve spools and needles. The hydraulic control system in this form extends in reality well into three dimensions, but is difficult to clearly show as such in drawings. For this reason, I have included in the drawings both a conventional diagrammatic showing in two dimensions of the preferred three-dimensional form of the valve assembly as contained in the broken-line box of FIGURE 1 and a symbolic representation of the hydraulic control assembly as shown in FIGURE 2. The various elements found in FIGURE 1, having counterparts in FIGURE 2, are similarly numbered.

Hydraulic control assembly **30** includes a housing block **34** having a first pressure chamber **35** and a second pressure chamber **36**. Inlet conduit **31** opens into the first pressure chamber **35**. Pressure chambers **35** and **36** are interconnected by conduit **37**. Second pressure chamber **36** is connected to hydraulic actuator **21** by pressure conduit **32** through a serially-connected, pilot-operated check valve **38**, arranged to permit free flow of fluid in excess of a minimum pressure from second pressure chamber **36** to hydraulic actuator **21** and to block the flow of fluid in the reverse direction except when the check valve is opened by hydraulic control pressure as described more fully below.

First pressure chamber **35** contains a reciprocating valve spool **39**, biased toward one end of the chamber by spring **40** and into a position placing inlet conduit **31** into fluid communication with connecting conduit **37** and in the position shown in FIGURE 1. Spool **39** is provided with a fine central orifice passage **41** passing through it from one end to the other. This permits fluid pressure introduced into one end of pressure chamber **35** by control conduit **42** from connecting conduit **37** to act on the opposite ends of spool **39**.

At the end of chamber **35** opposite the connection of control pressure conduit **42** is a spring-biased, adjustable pressure relief valve indicated generally at **43** and comprising a valve seat **44** and a valve closure member **45** urged against valve seat **44** by spring **46**. The tension of spring **46** is regulated by adjustable plug and control wheel **47** in a conventional manner. The downstream side of relief valve **43** is connected by conduit **48** to the return side of the hydraulic system as diagrammatically represented in the drawings by reservoir **49**.

It will be apparent that first pressure chamber **35**, together with valving spool **39**, pressure relief valve **43** and the interconnecting conduits described above, comprises a conventional pressure-reducing and -regulating valve which acts to deliver fluid to interconnecting conduit **37** at a relatively constant predetermined pressure

that is independent of pressure variations in inlet conduit 31.

Briefly, pressure control is accomplished in chamber 35 by a feedback of control pressure through conduit 42. Pressure increases in conduit 37 are reflected first in the upper end of chamber 35 tending to move spool 39 downwardly and against the force of spring 40. Fine orifice 41, passing through spool 39, permits this pressure to be reflected also in the lower end of chamber 35 and on the opposite end of spool 39. When and as long as the pressure in chamber 35, introduced through control conduit 42, exceeds the force of spring 46 in pressure relief valve 43, valve closure 45 will be unseated from valve seat 44, relieving the pressure on the downstream side of spool 39 and permitting it to be moved downwardly in chamber 35 by the pressure applied at its upper end. As spool 39 moves downward, the port in chamber 35 to interconnecting conduit 37 is partially or completely closed. Fine orifice 41 prevents the rapid equalization of pressure on the opposite ends of spool 39, but the pressure leakage permitted through it does tend to damp the action of the spool and permits the equalization of pressure on its opposite ends, at which time, valve closure 45 is again seated.

The pressure in conduit 37 and downstream of pressure-reducing and -regulating valve is thus maintained at a constant predetermined level as set by adjustment of compression in spring 46 and irrespective of changes in input pressure in conduit 31. In normal operation, hydraulic actuator 21 is supplied from the main hydraulic system with a constant predetermined pressure from pressure regulator and reducer chamber 35 through the remainder of control assembly 30. When the baling machine being controlled tends to stall or pressure in inlet condiut 31 to control assembly 30 exceeds a predetermined amount, the other elements of control assembly 30 operate as described below.

As shown in FIGURE 1, valve chamber 36 contains a double-spool valve member 50, biased toward the lower end of chamber 36 by spring 51. When valve member 50 is in its spring-urged position within chamber 36, upper spool 52 permits communication between connecting conduit 37 and outlet conduit 32 and closes off a port 53 connected to conduit 54 and the return side of the system as represented by reservoir 49. Lower spool 56 of valve member 50 permits communication between control conduit 57 connected to the pilot chamber of pilot-operated check valve 38 and outlet conduit 58 and the return side of the system.

The lower end of chamber 36 is connected to and reflects the pressure in inlet conduit 31 and upstream of the pressure-reducing and -regulating valve. This pressure is also reflected at the opposite end of valve member 50 as permitted by fine orifice 59 passing through the valve member from one end to the other. The upper end of valve chamber 36 and the end away from which valve member 50 is spring urged is connected to the return side of the system through a pressure relief valve indicated generally at 60 and comprising a valve seat 61 and a valve closure member 62 urged against it by spring 63. Relief valve 60 limits the pressure in the upper end of valve chamber 36 to a level determined by the tension in spring 63.

During normal operation of the baling system shown in FIGURE 1, valve member 50 is maintained in the position shown by spring 51, and by the hydraulic pressure acting on its upper end. As the pressure in inlet conduit 31 increases with main system work load, valve member 50 moves upwardly when the hydraulic force on its lower end exceeds the combined mechanical and hydraulic force opposing it. The required pressure level in inlet conduit 31 for shifting valve member 50 is determined by the setting of pressure relief valve 60 and the maximum pressure maintained thereby in the upper end of chamber 36 from and through fine orifice 59. The shift in valve member 50 disconnects connecting conduit 37 from outlet conduit 32 and reconnects the latter to return conduit 54 and reservoir 49. The shift in valve member 50 also transfers control conduit 57 of pilot-operated check valve 38 from communication with outlet conduit 58 and the return side of the system to connecting conduit 37. Outlet conduit 58 is closed.

The shift in valve member 50 from its position shown in FIGURE 1 to the upper end of pressure chamber 36 first dumps oil from the upstream side of the spring-biased closure member 64 of check valve 38 and transfers the supply of pressure-regulated fluid in connecting conduit 37 from actuator 21 to pilot chamber 65 of check valve 38. Spool 39 in the pressure-regulating valve shifts as necessary to bring up the pressure in connecting conduit 37 and pilot chamber 65 and thereby to unseat valve closure 64 in check valve 38. As check valve 38 is opened, fluid pressure is dumped from hydraulic actuator 21 through the check valve to the return side of the system.

Relieving the pressure supplied to hydraulic actuator 21 permits the throat or outlet orifice at the discharge end of the baler to open, reducing the resistance to the extrusion of material through it and thereby decreasing the main system work load as reflected in the pressure in main cylinder 11. As main system pressure decreases, valve member 50 is shifted downwardly and reset by spring 51 and the pressure developed in the upper end of chamber 36 through fine orifice 59 and as limited by relief valve 60 to its normal operating position as shown in FIGURE 1. Pilot piston 66 is urged downwardly in pilot chamber 65 by the spring 67 biasing valve closure 64 of check valve 38. Pressure-reduced and -regulated fluid is once again supplied from connecting conduit 37 to inlet conduit 32 and through check valve 38 to hydraulic cylinder 21 to build the pressure therein to its preset level.

From the foregoing, it will be apparent that my invention comprehends a control valve assembly which is able, first, to provide a regulated supply of fluid pressure to a load from an unregulated supply; second, to disconnect the regulated supply from the load when the unregulated source exceeds a predetermined maximum limit; and, third, to relieve fluid pressure built up in a load from the regulated supply. In the environment of the hydraulic-mechanical closed loop system and baling machine described above, the control assembly acts, first, to provide a regulated supply of fluid pressure to hydraulic actuator 21 controlling the throat of the baling chamber from the unregulated main system supply of pressure. Second, the assembly disconnects the regulated supply from actuator 21 when main system pressure exceeds a predetermined level as when increased by excessive resistance to the flow of material through the baling machine throat. Third, the control assembly embodying my invention automatically relieves the pressure in the hydraulic actuator 21 by transferring the regulated supply to the pilot pressure input of the pilot-operated check valve in the line to the hydraulic actuator. Because of the closed loop nature of the baling machine system, a hydraulic pressure developed in the main hydraulic system as a result of excessive resistance encountered in the throat of the baling chamber is reduced when the pressure in hydraulic actuator 21 is relieved.

The foregoing operation and function performed by the control assembly embodying my invention is able to achieve certain advantageous results in the operation of closed loop systems involving a hydraulic link, as, for example, the baling machine described above. Its operation is automatic. The source of unregulated main system pressure can be safely permitted to rise to a predetermined maximum level; at which time, the control assembly responds positively to limit the main system pressure to the predetermined maximum level. The control assembly limits and relieves excess main system pressure only by relieving the work load of the system. The control assembly does not limit main system pressure by direct relief

of pressure in the main system alone or even together with system load relief.

In the baling system described above and shown in the accompanying drawing, control assembly **30** limits the hydraulic pressure in the main system, as, for example, in conduit **27** and cylinder **11** or the blind side of piston **28** by passing to reservoir only fluid which has already passed check valve **38** and has been supplied to load-controlling hydraulic actuator **21**. No fluid from any other part of the hydraulic system is dumped or directed to reservoir by control assembly **30**. Operation is continued without a stall and without wasting time and power to rebuild lost main system pressures. Only a minimal amount of fluid is dumped to the return side of the system from the hydraulic actuator controlling the size of the variable orifice or throat of the baling chamber. This particular hydraulic actuator preferably has a short stroke and is linked to the orifice structure in a manner that permits substantial variation in orifice size to be accomplished by adding or taking small amounts of fluid to or from the actuator cylinder. Thus, the desired control function is achieved with a minimum loss of power and of time and with high efficiency.

The high unregulated pressures in the main hydraulic system are imposed only on the inlet side of the pressure-reducing and -regulating valve portion of the assembly. The valves and passages in the main fluid control valve section of the control assembly are subjected only to a reduced and regulated and limited level of fluid pressure. Operating pressure supplied to it is controlled by the regulating valve portion of the control assembly. Further, it is protected from the transfer back of high pressures to it from the load-responsive hydraulic actuator by the pilot-operated check valve on the load side of the assembly. This check valve, however, is always positively powered by a regulated supply pressure and can be quickly opened to reduce pressure developed in the load actuator and, thus, to relieve main system pressure.

The pilot-operated check valve on the load side of the assembly also acts to positively maintain any pressure present on the load-controlling actuator even when the main system pressure is reduced to zero and/or the system shut down. In continuous baling machines, for instance, it is important to be able to hold tension of the bale of material standing in the throat or variable orifice of the baling chamber during periods when the machine might be shut down. Otherwise, when operation of the machine is resumed, the necessary resistance to the displacement of the baling head will be lacking so that subsequent bales will be soft and of low density until tension is restored to a proper level. In the control system embodying my invention, only the seal in the final pilot-operated check valve need be maintained to preserve pressure in the load. The other seals in the control assembly are protected from such pressure by the final check valve. The spools and their seals in the control valve section of the system are not necessarily well adapted to hold high-standing pressures without leakage and they are not subjected to nor relied on for maintaining load pressure in the control system described above.

Those skilled in the art will appreciate that various changes and modifications can be made in the apparatus described herein without departing from the spirit and scope of the invention.

I claim:

1. A hydraulic control apparatus for supplying fluid pressure to and releasing fluid pressure from a hydraulic load in accordance with the level of supply pressure and comprising

a hydraulic load having an inlet connection,

a pilot-operated check valve having a pair of fluid pressure ports and a through flow path extending between and connecting them and having a pilot pressure port, the port at one end of said flow path being connected to said inlet connection of said hydraulic load to provide free and unchecked conduction through said check valve toward said load and pilot pressure-controlled conduction through said check valve in a direction away from said load,

a pressure supply conduit,

control means connected to the port at the other end of said flow path and to said pilot pressure port of said check valve on the one hand and to said pressure supply conduit and to atmosphere on the other, said control means having valve means movable from a first position connecting said pressure supply conduit and atmosphere to the port at the other end of said check valve and its pilot pressure port respectively and a second position reversing said first position connections, said valve means having a control pressure port connected to said pressure upply conduit and being movable from said first position to said second position in response to pressure in said pressure supply conduit in excess of a predetermined level.

2. The apparatus of claim **1** together with means resiliently biasing said valve means of said control means toward its said first position for returning said valve means from its said second position to its said first position when pressure in said pressure supply conduit is less than a predetermined level.

3. The apparatus of claim **1** together with a fluid pressure regulator inserted in said pressure supply conduit at a point that is upstream of said control means for providing a regulated supply of fluid pressure from said supply conduit to said control means and that is also downstream of said control pressure connection of said valve means to said pressure supply conduit for providing unregulated supply conduit fluid pressure to said control means.

4. The apparatus of claim **1** in which said control means comprises

a pressure chamber at one end of which said control pressure port enters and having a normally closed pressure relief port entering at its other end, said pressure relief port being responsive to open to atmosphere when the pressure in said other end of said chamber exceeds a predetermined opening level,

and in which said valve means comprises

a valve element slidable in said chamber to and between said first and second positions of said valve means in accordance with the pressure in said chamber at opposite ends of said valve element, said slidable valve element having a fine passage extending to and between its opposite ends,

and also comprising

spring means for resiliently urging said valve element toward said first position in said chamber and toward said control pressure port,

whereby said valve element moves toward said second position by pressure in excess of said predetermined opening level of said normally closed pressure relief port and introduced to said chamber by said control pressure port from said pressure supply conduit and returns to said first position as urged by said spring when the chamber falls below said predetermined opening level.

5. A hydraulic control apparatus comprising the combination of

a pilot-operated check valve having a first port and a second port and a through flow path extending between and connecting them and having a pilot pressure port and valve means in said flow path permitting free fluid pressure conduction through said valve from said first to said second ports and pilot pressure-controlled conduction through said valve from said second to said first ports,

a control valve comprising

a chamber connected by conduits to said first port and said pilot pressure port of said check valve, said chamber also having an inlet passage for supply pressure, a relief passage, a normally

closed pressure-responsive relief passage and a valve-operating passage in communication externally of aid chamber with said inlet passage and

a movable valve means in said chamber for controlling fluid pressure communication between said inlet and relief passages on one hand and said first port and said pilot pressure port of said check valve on the other,

a pressure-communication passage connecting said chamber on one side of said valve means with said chamber on the other side of said valve means,

said valve means being spring biased to a first position connecting said inlet passage to said first port of said check valve and said relief passage to aid pilot pressure port of said check valve, and said valve means being biased to a second position connecting said inlet passage to said pilot pressure port of said check valve and said relief port to said first port of said check valve by supply pressure in said valve-operating passage acting directly in said chamber on said one side of said valve means and indirectly through said pressure-communication passage on said other side of said valve means,

said pressure relief passage entering said chamber on said other side of said valve means and responsive to open and to relieve pressure in said chamber above a predetermined level.

6. In apparatus for applying a compressive force on material collected in a chamber and against a controllable resistance comprising a variable orifice and having a source of limited hydraulic pressure connected to and supplying a hydraulic ram for supplying said force up to the pressure limit of said source and a hydraulic actuator connected to and supplied by said source for controlling the magnitude of said resistance,

the combination with said hydraulic actuator of a hydraulic control apparatus for supplying fluid pressure to and releasing fluid pressure from said hydraulic actuator in accordance with the level of source pressure supplied to said hydraulic ram,

a pilot-operated check valve having a pair of fluid pressure ports and a through flow path extending between and connecting them and having a pilot pressure port, the port at one end of said flow path being connected to said hydraulic actuator to provide free and unchecked conduction through said check valve toward and to supply said hydraulic actuator and pilot pressure-controlled conduction through said check valve in a direction away from and to unload said hydraulic actuator,

a pressure supply conduit for supplying pressure proportional to pressure in said ram during application of a compressive force,

control means connected to the port at the other end of said flow path and to said pilot pressure port of said check valve on the one hand and to said pressure supply conduit and to atmosphere on the other, said control means having valve means movable from a first position connecting said pressure supply conduit and atmosphere to the port at the other end of said check valve and its pilot pressure port respectively for supplying operating pressure to said hydraulic actuator and a second position reversing said first position connections for drawing off and unloading operating pressure from said hydraulic actuator, said value means having a control pressure port connected to said pressure supply conduit and being movable from said first position to said second position in response to pressure in said pressure supply conduit in excess of a predetermined level.

7. The apparatus of claim **6** together with means resiliently biasing said valve means of said control means toward its said first position for returning said valve means from its said second position to its said first position when pressure in said pressure supply conduit is less than a predetermined level.

8. The apparatus of claim **6** together with a fluid pressure regulator inserted in said pressure supply conduit at a point that is upstream of said control means for providing a pressure-regulated supply of fluid pressure from said supply conduit to said control means and that is also downstream of said control pressure connection of said valve means to said pressure supply conduit for providing unregulated supply conduit fluid pressure to said control means.

9. The apparatus of claim **6** in which said control means comprises

a pressure chamber having said control pressure port enter at one end and having a normally closed pressure relief port entering at its other end, said pressure relief port being responsive to open to atmosphere when the pressure in said other end of said chamber exceeds a predetermined opening level,

and in which said valve means comprises

a valve element slidable in said chamber to and between said first and second positions of said valve means in accordance with the pressure in said chamber at opposite ends of said valve element, said slidable valve element having a fine passage extending to and between its opposite ends,

and also comprising

spring means for resiliently urging said valve element toward said first position in said chamber and toward said control pressure port,

whereby said valve element tends to move toward said second position in response to pressure in excess of said predetermined opening level of said normally closed pressure relief port and introduced to said chamber by said control pressure port from said pressure supply conduit and tends to return to said first position as urged by said spring when the chamber pressure falls below said predetermined opening level.

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