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LOWERING VALVE

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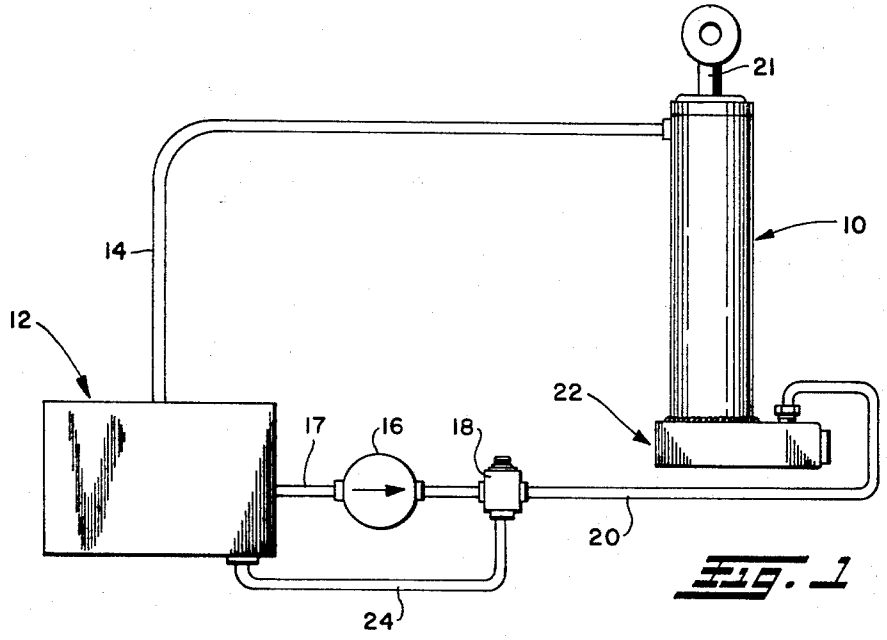


Fig. 1

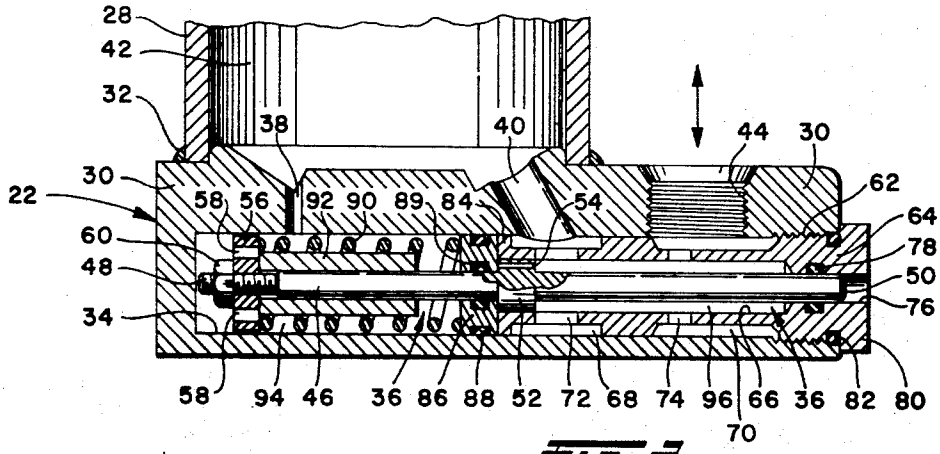


Fig. 2

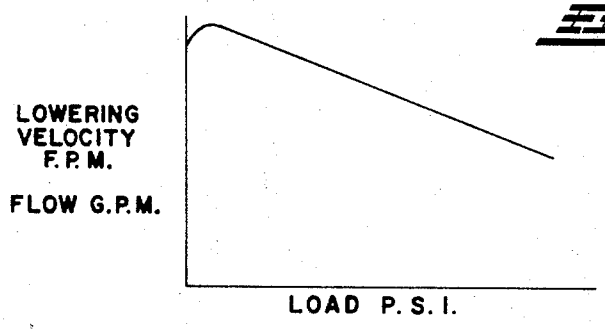


Fig. 3

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LOWERING VALVE

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ABSTRACT OF THE DISCLOSURE

A lowering valve for an industrial lift truck is placed in a hydraulic circuit in such a position as to be subjected to load lifting and lowering hydraulic pressure. The valve responds to hydraulic pressure during load lowering to regulate the load velocity during lowering.

This invention relates to a flow regulator valve, and more particularly to a flow regulator valve such as used in cooperation with a lifting ram comprising a cylinder and piston movable in the cylinder for lifting a load.

Although many and diverse uses of the invention will no doubt become apparent to persons skilled in the art as the description proceeds, it is desirable to relate in detail only one application of the invention which has proven to be of great value.

In the operation of industrial lift trucks, loads supported by the lifting hoist cylinder during vertical movement of the telescopic mast located at the front of the truck vary widely. The tendency during lowering movement of the load is that the lowering speed increases as the mass of the load supported by the elevating device and hoist cylinder increases. Such a direct relationship between increasing load and lowering speed is undesirable.

In the operation of industrial lift trucks, it is customary to provide means at the inlet end of the lifting cylinder ram whereby, should a hose or other conduit leading to the cylinder become ruptured, the piston will not move to lower the load faster than at a predetermined rate. In other words, a flow regulator as used in an industrial lift truck is a regulating device applied to a load lifting ram for the purpose of preventing rapid downward movement of the lifting piston. In the event of a malfunctioning or damage of the hydraulic circuit that normally channels the downward movement of the lifting piston, it also becomes a safety device.

Flow regulators are very old in the art, and many patents have issued covering various mechanisms for contributing the results required. In general, however. flow regulators depend for their operation upon the dynamic flow of fluid from beneath a piston as it moves downwardly in a cylinder. Such flow regulators are not completely desirable because there is a time delay prior to the effective functioning of the built-in metering mechanism. Further, flow regulators of the type using dynamic flow are not generally as sensitive as is required. Even further, flow regulators of the prior art contribute resistance to the flow of fluid under pressure into the cylinder for lifting a load. For efficient operation of the hydraulic system, the flow regulator should impose minimum resistance to the flow of fluid into the cylinder for lifting the load.

It is the primary object of this invention to provide an improved regulator valve for use with hydraulic devices of the class comprising a cylinder and a piston movable in the cylinder for lifting and lowering a load.

An important object of this invention is to provide an improved regulator valve for use with fluid actuated hoist cylinders wherein the speed with which the load is lowered by the hoist decreases as the load thereon increases.

A further object of this invention is to provide an improved flow regulator valve that does not depend for its operation on the velocity of fluid flowing through the valve.

A further object of this invention is to provide a flow regulator valve that does not depend on a delay time to operate, but which is adapted to be set at all times should there be a malfunctioning of the hydraulic circuit that normally controls the downward movement of the lifting piston.

In carrying out the above objects, there is provided in this invention a flow regulator valve comprising a piston rod that is in communication with a ram cylinder by means of a very small orifice or passage. The piston rod is positioned in a valve chamber with its forward end exposed to the small orifice extending to the ram cylinder. The rearward end of the piston rod extends outwardly of the valve chamber in communication with atmospheric pressure through actual exposure to the atmosphere or through connection to a sump. The piston rod is biased through the intermediary of a spring lying between the forward end of the piston rod and a sealing piston slideably mounted on the piston rod. The sealing position in turns bears against a fixed portion of the valve chamber, preferably in the form of a shoulder formed in a bore functioning as the valve chamber. Fixed to the piston rod and bearing against the sealing piston is a metering land. The metering land is in a position to move in the valve chamber for closing a relatively large orifice through which fluid under pressure moves from a source of fluid pressure into the hydraulic ram cylinder.

Because the effective area of the forward end of the piston rod of the flow regulator valve (lying forward of the sealing piston) is larger than the effective area of the rearward end of the piston rod (at the rear of the sealing piston) due to the exposure of the rearward end of the piston rod to the atmosphere, it will be seen that any differential in pressure between the lower end of the cylinder and the valve chamber will immediately be sensed by the piston rod so that the piston rod will move the metering land relative to the large passage or orifice in the valve body. If now, control means at the source of pressure are actuated to permit flow of fluid from the cylinder so as to lower a load, the load will be lowered in accordance with the prior positioning of the metering land.

Let us assume that the load is to be raised. At that time the inward flow of fluids from the source of fluid pressure will bring about an unbalancing of the pressure between the valve chamber and the ram cylinder due to dynamic flow. This differential in pressure will be exerted immediately against the sealing piston which will move away from its shoulder and will react against the spring between it and the piston rod. The spring will yieldingly move the piston rod and the metering land to open fully the means of communication to the ram cylinder. In effect, this invention utilizes a metering device always effective to control lowering of the load, but immediately movable out of position by fluid pressure upon lifting of the load. This last movement during lifting of the load is preferably obtained through the use of a spring which is conditioned or stressed by the lifting pressure.

The above and further objects, features and advantages of this invention will become apparent to those familiar with the art from the following detailed description of a preferred embodiment of the invention, as illustrated in the accompanying drawing wherein:

FIGURE 1 is a schematic view of a fluid actuated hoist motor and elements associated therewith providing pressurized fluid to the hoist cylinder through a regulator valve device located in the base end of the cylinder;

FIGURE 2 is an enlarged sectional view taken axially

through the flow regulator valve assembly in association with the base end of the cylinder of FIGURE 1; and

FIGURE 3 is a graph illustrating a typical performance curve of the flow regulator valve.

Turning now to the details of the present invention, as illustrated in the drawing, FIGURE 1 illustrates a hydraulic hoist cylinder **10** of the piston type which may be used, for example, in elevating loads of widely varying mass as in the lifting mast structure of an industrial lift truck. The cylinder **10**, as illustrated, is of the single acting type, the top end being vented to a sump **12** by way of a conduit **14**. The sump **12** is connected to a pump means **16** by a conduit **17**. The pump may be of any suitable type for supplying pressurized fluid, at the selection of an operator (through a selector valve **18**), by way of conduit **20** to the working end of a piston (not shown). The piston is connected to an extensible piston rod **21** of motor **10**. A regulator valve device **22** is attached to the base end of the cylinder **10**. During retraction of piston rod **21**, hydraulic fluid returns to the sump **12** through the valve device **22**, conduit **20**, selector valve **18** and fluid return conduit **24**. Flow regulator valve **22** comprises the subject matter of the present invention and will now be described in detail in conjunction with FIGURES 2 and 3.

It should be understood that the piston-cylinder type of hydraulic actuator as shown schematically in FIGURE 1 is illustrated for purposes of showing the preferred embodiment of this invention. The flow regulator valve of this invention is not to be considered as limited to the fluid actuated hoist cylinder of FIGURE 1.

In the base end of cylinder tube **28**, FIGURE 2, of the cylinder **10** is secured a valve housing **30** by means of a weld **32**. Other means of attaching valve housing **30** to cylinder **28** such as by means of screw threads are equally considered within the scope of this invention. Valve housing **30** is defined by a central bore **34** extending from a first open end of the valve housing **30** to a second closed end of the valve housing thereby defining a valve chamber **36**. Passageways **38** and **40** provide a means of communication between the central bore **34** and the interior **42** of the cylinder tube **28** of cylinder **10**. As shown in FIGURE 2, valve housing **30** includes a tapped hole **44** defining an inlet and outlet passageway of the regulator valve. The threads are provided for a tube connection to establish a fluid tight tube joint between the valve housing **30** and conduit **20**, FIGURE 1. The particular tube connection between the valve housing and the conduit forms no part of this invention and any coupling within the skill of the art may be considered within the scope of this invention. In the interest of clarity the tube **20** of FIGURE 1 is not shown in FIGURE 2. It is to be understood, however, that tube **20** communicates with the central bore **34** by means of the tapped hole **44**.

Disposed within the central bore **34** is a piston rod **46** having a first end **48** and a second end **50**. Intermediate end **48** and **50** of piston rod **46** is an enlarged portion defining a metering land **52**. As shown in the preferred embodiment of FIGURE 2, metering land **52** is of a generally cylindrical configuration although such a configuration should not be considered as limiting to this invention. Defined in the metering land **52** is a metering land passageway **54** to provide communication from one end of the metering land to the other for a purpose to be more fully described hereafter. It should be understood that as shown in the preferred embodiment the metering land **52** is an integral part of the piston rod **46**. It is contemplated that the metering land could be a separate element secured to the piston rod by suitable connecting means.

Provided at end **48** of piston rod **46** is an annular disc **56** in which are defined passages **58**. As shown in FIGURE 2, annular disc **56** is slideably received over the end **48** of piston rod **46** and is retained in place by a nut **60** threadedly advanced over the end **48** of piston rod **46**. The purpose of annular disc **56** is to provide a shoulder means for the spring **90**. It is to be understood that equally within the scope of this invention would be an integral shoulder formed on the end **48** of the piston rod **46**, such shoulder including transverse passageways **58** for a purpose to be more fully described hereafter. Further, it is contemplated that a shoulder means could be staked to the piston rod.

Included in the walls defining bore **34** at the open end of valve housing **30** are threads **62** for the purpose of receiving a valve insert **64**. Valve insert **64** is a generally cylindrical element including an insert counterbore **66** in which is received the metering land **52** of piston rod **46**. Defined in the exterior surface of valve insert **64** are annular grooves **68** and **70**. Said annular grooves communicate with counterbore **66** by means of passageways **72** and **74** respectively. End **50** of piston rod **46** is received in bore **76** of valve insert **64**. Bore **76** is defined by an annular groove to provide a space for sealing O-ring **78**. The purpose of O-ring **78** is to provide a seal between chamber **96** and atmosphere or tank and yet permit the piston rod **46** to reciprocate with respect to the valve insert **64**. In the preferred embodiment of FIGURE 2, an O-ring is shown as the sealing means although it should be understood that other seals such as gland seals or diaphragm seals are equally within the scope of this invention. In assembly, the valve insert **64** is threadedly advanced into the valve housing **30** until head **80** bottoms on the exterior surface of the valve housing. To provide sealing between the valve housing **30** and valve insert **64**, a seal at **82** may be provided in the form of an O-ring. Other seals may be considered equally within the scope of this invention.

As shown in its fully assembled condition in FIGURE 2, the inner end of valve insert **64** defines a shoulder **84**. Positioned adjacent the shoulder **84** is a sealing piston **86**. Sealing piston **86** is generally cylindrical in shape and includes a bore through which the piston rod **46** extends. Defined in the exterior cylindrical surface of sealing piston **86** is an annular groove for the purpose of receiving an O-ring seal **88**. Similarly, defined in the bore of the sealing piston is an annular groove for the purpose of receiving an O-ring seal **89**. It should be understood that the sealing piston is free to reciprocate with respect to both the valve housing **30** as well as the piston rod **46**. Seals **88** and **89** provide sealing while allowing relative movement between the respective elements. Thus, while free to reciprocate in bore **34** of the valve housing **30** the sealing piston provides means to isolate subchambers **94**, **96** in the larger valve chamber **36**. Equally within the scope of this invention should be considered sealing means on the metering land as a means of isolating subchambers **94**, **96**.

Disposed between the sealing piston **86** and the annular disc **56** is a spring **90**. A spring guide **92** in the form of a hollow cylinder is slideably disposed over the piston rod **46** between the piston rod and the spring **90**. The purpose of the spring guide **92** is both to support the spring **90** and also to act as a stop means as will be more fully described hereafter.

The operation of the flow regulator valve of this invention will now be described. With the ram piston holding a load the pressure in the cylinder interior **42** is the same as in the chambers **94**, **96** of the valve. The pressure in chamber **94** is received by means of passageway **38**. Due to the presence of passages **58** in the annular disc or shoulder **56** the pressure in chamber **94** exerts a force on the end **48** of the piston rod **46**. This force acts in a direction to thhe right of FIGURE 2 and is of a magnitude that is the product of the pressure times the cross-sectional area of the piston rod **46**. In chamber **96**, however, fluid pressure is not acting on the piston rod as the end **50** of the piston rod is exposed to the atmosphere. There are no effective forces acting on the metering land **52** of the piston rod **46** due to the presence of the metering land passageway **54** which maintains the meter-

ing land in a balanced condition. Therefore, the net forces acting on the valve during a period of holding a static load are (a) the force acting on the end **48** of the piston rod **46** and acting to the right of FIGURE 2, (b) the force of atmosphere acting on the end **50** of piston rod **46** and acting to the left of FIGURE 2, (c) the spring **90** tending to resist movement of the piston rod **46** to the right of FIGURE 2. Therefore, by selecting an appropriate spring rate for spring **90** and with a condition wherein the pressure in the cylinder interior is greater than atmospheric pressure, the net force acting on the piston rod will tend to move the piston rod to the right of FIGURE 2 thereby moving the metering land **52** into a position so as to restrict the passageway **72**. The total amount of movement to the right of FIGURE 2 will depend on the effective force acting to the right in view of the spring rate. The spring guide **92** will act as a stop in abutting the sealing piston **86**. Thus, the metering land **52** cannot move so far to the right of FIGURE 2 that the passageway **72** would become completely restricted unless so designed. As the metering land moves to the right the flow of fluid from the cylinder interior **42** via the passageway **40** to the outlet **44** is thereby metered. This metering increases with increasing load thus resulting in an inverse relationship between the flow of fluid and load. This inverse relationship is shown diagrammatically in FIGURE 3.

An important feature of this invention is that the positioning of the metering land **52** with respect to the passageway **72** is not dependent on fluid flow. That is, it is not necessary for a predetermined flow rate to be achieved through either passageway **38** or **40** to position the metering land so as to constrict the flow of fluid through passageway **40**. The metering land **52** of this invention will be positioned relative to the passageway **72** even when there is no flow. Piston rod **46** of this invention senses the difference between the pressure in the cylinder interior **42** and atmospheric pressure. Since atmospheric pressure is relatively constant, the flow regulator valve of this invention has a stable reference point with which to determine pressure conditions in the cylinder interior. In this respect the flow regulator valve of this invention is to be differentiated from flow regulator valves of the prior art including the Arbogast Patent No. 2,988,060 (91–443). Arbogast teaches a piston rod exposed to varying pressures in chambers of the valve itself. The piston rod of Arbogast therefore senses the difference in pressures in various chambers of the valve in order to position a metering land with respect to the outlet orifice. Because pressure conditions within the valve vary widely it has been found that measuring the difference in pressures in various chambers in the valve does not provide a reliable method of positioning the metering land with respect to the outlet orifice. In applicant's device, the relatively stable source of atmosphere is the reference point against which pressures in the cylinder interior are measured.

The operation of the flow regulator valve of this invention during a lifting cycle of the ram piston will now be considered. In the lift cycle fluid flows through conduit **20** (FIGURE 1) into passageway **44**, annular groove **70**, passageway **74**, counterbore **66**, passageway **72**, annular groove **68**, passageway **40**, and thereafter to the cylinder interior **42** to lift the ram piston (not shown). During this lift cycle it is desired that the valve impose as little resistance as is possible to the flow of fluid into the cylinder interior **42**. In applicant's device the dynamic flow of fluid through passageway **40** creates a differential in pressure between chamber **96** and cylinder interior **42**. The pressure in chamber **96** during this condition is higher than the pressure in the cylinder interior **42** and consequently the chamber **94**. Therefore, the pressure available at the end **48** of the piston rod **46** is relatively small as compared to the pressure exerted on the sealing piston **86** by means of the metering land passageway **54**. The net effect is that the differential in pressures developed through the passageway **40** will move the sealing piston **86** to the left of FIGURE 2 compressing spring **90**. A compression of spring **90** will move the piston rod **46** to the left of FIGURE 2 and thus move the metering land **52** toward the left to fully open the passageway **72** leading to the cylinder interior **42**. Thus, there will be a minimum of resistance to the flow of fluid from the inlet **44** to the cylinder interior **42** as the metering land **52** is fully retracted from constricting passageway **72**.

To briefly summarize the operation of the flow regulator valve of this invention, two distinct functions will be observed. To the left of the sealing piston **86** of FIGURE 2 the piston rod **46** performs a sensing or weighing function. To the right of the sealing piston **86** the piston rod through the medium of the metering land **52** performs the metering or flow controlling function of the valve. The sealing piston **86** insures that the respective chambers **94**, **96** to the right and left of the sealing piston will remain independent. During the lifting cycle of the hoist motor the sealing piston **86** is subjected to a differential in pressure causing said sealing piston to move to the left of FIGURE 2 thereby causing the piston rod **46** and metering land **52** to move to the left and, thus, fully uncover the passageway **72**.

The passageway **72** which might appropriately be labelled a control orifice may take many forms. A plurality of circular apertures may be provided in the valve insert **64**. Similarly, a plurality of elongated slots or a single elongated slot may be provided in the valve insert **64** to thereby define a passageway **72** from the passageway **40** to the counterbore **66**. By altering the configuration of the passageway **72** as well as the spring constant of spring **90** it is possible to produce an unlimited number of flow characteristics induced by pressure in the cylinder interior. The curve of FIGURE 3 is shown for purposes of illustration only in order to point out a typical flow curve for the carriage of an industrial lift truck. The curve may be varied, as was previously pointed out, by altering the configuration of passageway **72**.

In the preferred embodiment of this invention, the passageway **38** is a drilled hole of .015 inch diameter. This dimension should not be considered as limiting to this invention, however, as the passageway diameter may vary to meet a variety of conditions such as valve size, cylinder diameter, etc. Similarly, the size of passageway **40** may vary depending on the flow rates of the valve.

From the foregoing, it will appear that an excessive rate of descent of the carriage is prevented by the gradual closure of the passageway **72** by the metering land **52**. Such a closure of the control ports is brought about by the sensing of a pressure differential between atmospheric pressure and fluid pressure within the cylinder interior. This pressure differential causes the valve to be pre-set, thereby eliminating the delay time usually encountered in valves of the class wherein a flow of fluid is required to set the controlling means. Thus, should there be a failure in the valve means which controls the flow of fluid from the motor cylinder to the sump through conduit **20**, or whenever there is a fracture in the conduit **20** or conduits connected therewith, the valve mechanism of FIGURE 2 will provide a reliable safety means for controlling the rate of descent of the industrial lift truck carriage.

While we have shown and described preferred embodiments of the invention, it will be apparent that numerous variations and modifications may be made without departing from the underlying principles of the invention. It will be apparent to those familiar with the art that by coupling the valve of this invention to other mechanisms by mechanical linkage or electronically such as by a potentiometer or warning light, that the use of the valve of this invention will be enhanced by lending it to broader application. The valve of this invention then

might be used as a safety indicator as in warning of impending instability. Some other uses might be:

(a) weighing a load,
(b) preventing hoisting in an overload condition,
(c) cutout of drive controls because of an overload or instability,
(d) progression of limiting of travel speeds proportionate to the loads carried.

We therefore desire, by the following claims to include within the scope of the invention all such variations and modifications by which substantially the results of the invention may be obtained through the use of substantially the same or equivalent means.

What is claimed is:

1. A valve device for use with a hydraulic motor of the class including a ram cylinder and a load piston movable therein, said valve device comprising:

a valve body having an open end, an elongated bore therein and

first and second passageways leading from said elongate bore to the exterior surface of said valve body for communication with said ram cylinder;

a piston rod slideably disposed in said elongate bore and having the forward end thereof exposed to pressure applied through said first passageway from said ram cylinder;

the rearward end of said piston rod extending outwardly of said valve body through said open end and exposed to atmospheric pressure;

metering means operably associated with said piston rod and movable thereby to control the size of said second passageway in response to pressure differential existing across the piston rod; and

said valve body including outlet means in communication with said second passageway for permitting the flow of fluid from said elongate bore.

2. The valve device of claim 1 in which said metering means is defined by a metering land fixed to said piston rod, said metering land slideably disposed in said elongated bore.

3. The valve device of claim 2 in which sealing means are provided in said elongated bore between said first passageway and said second passageway.

4. The valve device of claim 3 in which said sealing means comprises a cylindrical sealing piston slideably disposed over said piston rod between said metering land and said forward end of said piston rod.

5. The valve of claim 4 in which shoulder means is provided on said forward end of said piston rod and a spring is captured between said sealing piston and said shoulder to bias said sealing piston against said metering land, and an axial passageway is provided in said metering land to provide fluid communication from said second passage to said sealing piston.

6. The valve of claim 5 in which a hollow cylindrical element is disposed over said piston rod between said shoulder and said sealing piston, the outer diameter of said cylindrical element being approximately equal to the inner diameter of said spring, the axial length of said cylindrical element being less than the distance between said sealing piston and said shoulder while said sealing piston abuts said metering land.

7. A valve device for use with a hydraulic motor of the class including a ram cylinder and a load piston movable therein, comprising:

(a) a valve body having an elongated bore extending from a first open end of said body to a second closed end of said body,

(b) first and second spaced passageways leading from said elongated bore to the exterior surface of said valve body for communication with a ram cylinder, said first passageway being relatively small and said second passageway relatively large,

(c) a valve insert disposed in said first open end of said valve body, said valve insert including a generally cylindrical outer surface and a central bore and counterbore,

(d) a piston rod slideably disposed in said elongated bore and having its forward end exposed to pressure applied through said first passageway from a ram cylinder and its rearward end extending outwardly of said valve body through said central bore of said valve insert,

(e) sealing means between said rearward end of said piston rod and said valve body,

(f) at least one radial passageway in said valve insert providing communication between said counterbore of said valve insert and said second passageway through an annular groove of said valve insert,

(g) passageway means between said radial passageway and said counterbore of said valve insert communicating with a source of fluid pressure,

(h) a metering land secured to said piston rod and disposed in said counterbore adjacent said radial passageway,

(i) the inner end of said valve insert defining a shoulder in said elongated bore of said valve body,

(j) shoulder means disposed on said forward end of said piston rod,

(k) a sealing piston disposed between said metering land and said shoulder means, said sealing piston including sealing means between said valve body and said piston rod,

(l) a spring disposed between said sealing piston and said shoulder means to bias said sealing piston against said shoulder of said elongated bore,

(m) an axial passageway in said metering land to provide communication between said second passageway and said sealing piston,

(n) stop means defined by a hollow cylindrical element disposed between said sealing piston and said shoulder of said piston rod.

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