# United States Patent

**Williams**

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## [54] SELF-LOCKING HYDRAULIC LINKAGE


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[73] Assignee: **The United States of America as represented by the Secretary of the Army**



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[52] **U.S. Cl.** ..... **89/40 J**, 188/280, 188/317, 188/320

[51] **Int. Cl.** ..... **F41f 23/34**

[58] **Field of Search** ..... 89/37 R, 37 G, 37 H, 37 L, 89/40 R, 40 J, 43; 188/280, 313, 320



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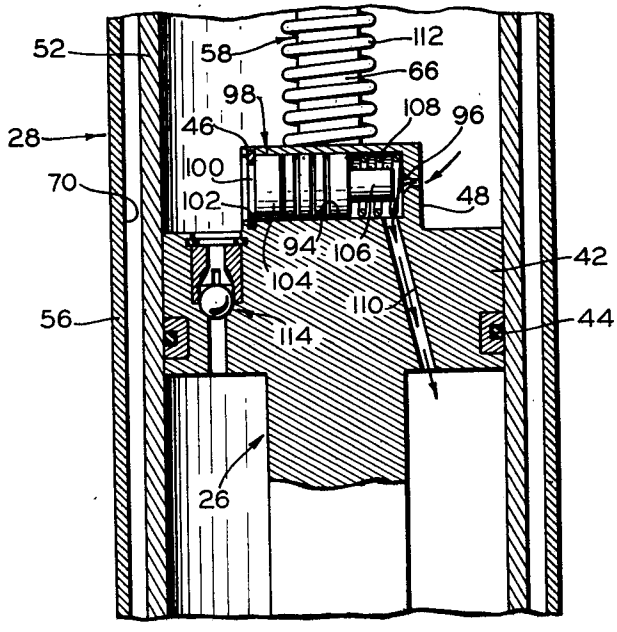
[57] **ABSTRACT**

A self-locking hydraulic piston and cylinder arrangement interposed between a stationary and a movable member is provided with a slidable poppet valve in the heat of the piston. The valve is normally spring biased to a fully open position to permit a slightly restricted passage of hydraulic fluid through the piston head during the movement of the pivotal member relative to the stationary member. However, when the poppet valve is subjected to a differential pressure in excess of the spring bias thereagainst, it is automatically actuated to block the passage of the hydraulic fluid through the piston heat thereby preventing further relative movement between the piston and cylinder which then acts as a rigid link between the movable and stationary members.


**11 Claims, 6 Drawing Figures**



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SHEET 1 OF 2

Fig. 1

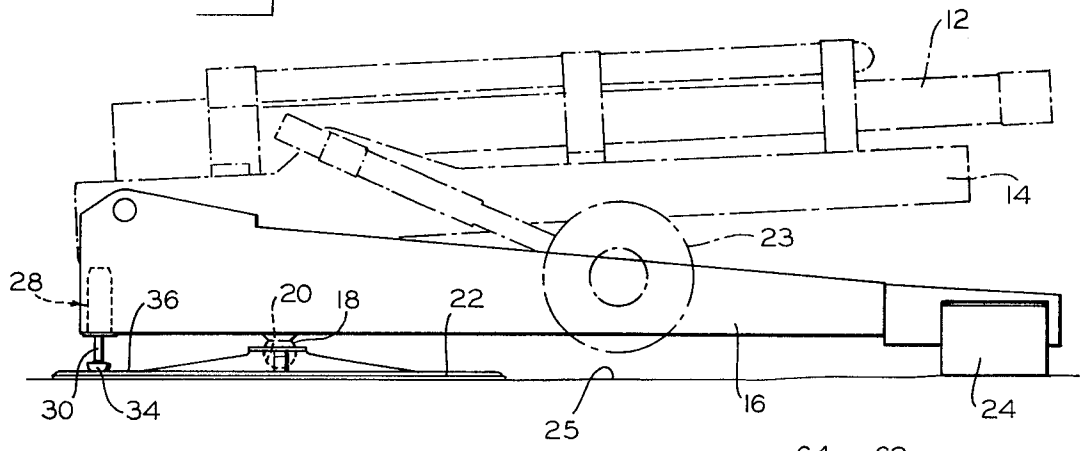


Fig. 2

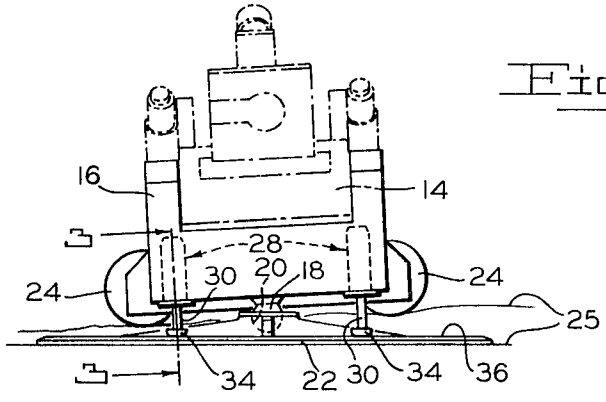


Fig. 3

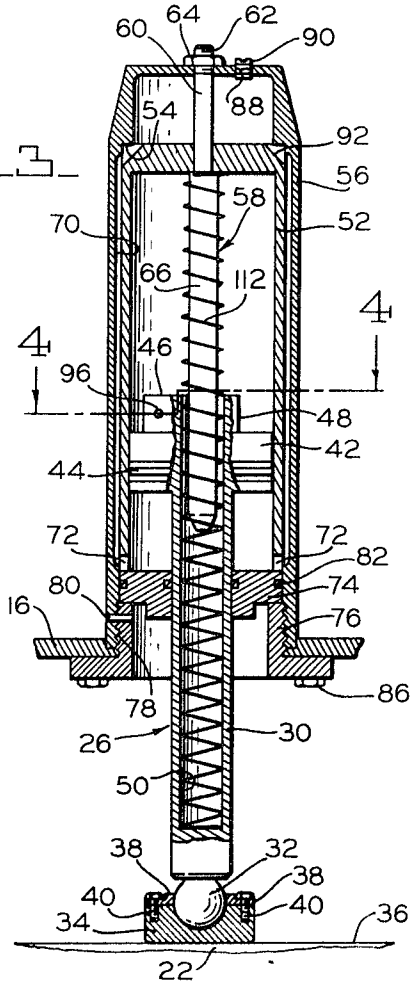


Fig. 4

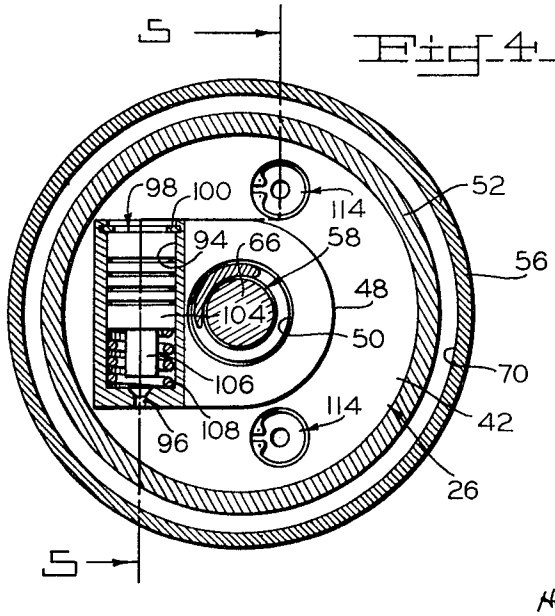


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Fig. 5

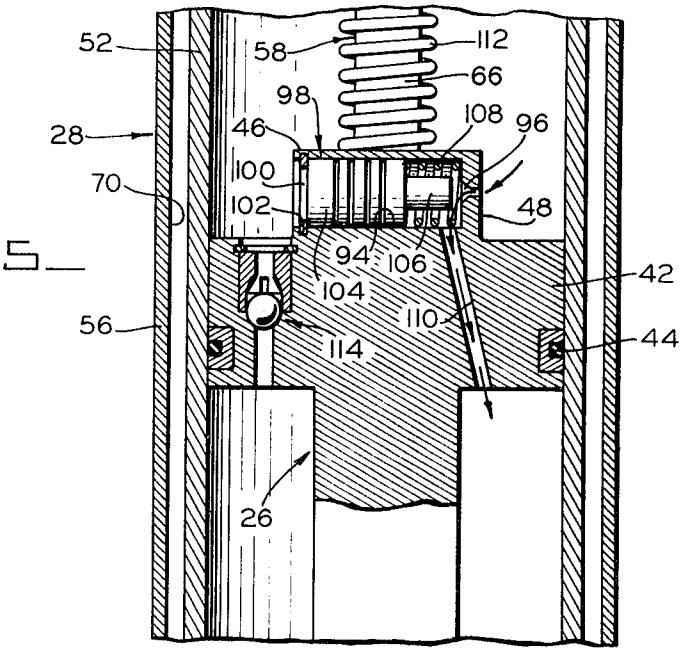
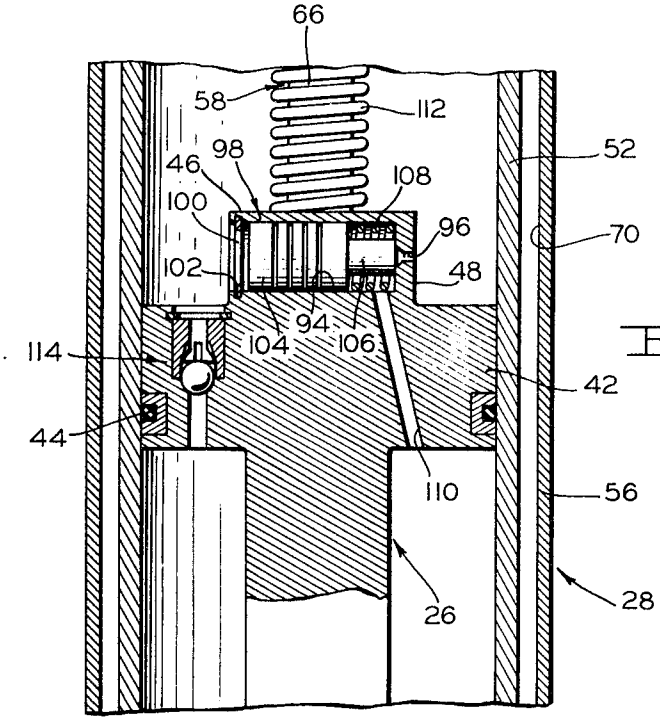



Fig. 6

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# SELF-LOCKING HYDRAULIC LINKAGE

## BACKGROUND OF THE INVENTION

This invention relates to a hydraulic linkage adapted to operate between a movable first member and a stationary second member and is more particularly directed to linkage of this type which will lock against further movement whenever the velocity resulting from the load applied thereto by the movable member exceeds a given rate.

In certain mechanical structures wherein one member is movably secured to a second stationary member, it is often necessary to provide a relatively slow movement of the movable member during one phase of the operation of the mechanical structure and yet prevent any significant movement of the movable member during another phase of operation. A specific example of such arrangement can be found in a large caliber gun such as a towed howitzer wherein the rearward end of the carriage therefor is rotatably mounted on the center of a stationary baseplate arranged to be placed on the ground while the forward end of the carriage is provided with a pair of spaced rollers which ride along the ground during the traverse of the carriage about the baseplate. In the event the howitzer is emplaced on uneven terrain, it is quite possible that the traverse required to bring the gun into firing alignment with a selected target will terminate with the rollers in a higher or lower plane than the baseplate or with one of the rollers in a different plane than the other. As a result, the carriage will be canted relative to the baseplate and, consequently, invite physical displacement thereof in response to the recoil forces imparted thereto by the firing of the gun. Under certain conditions, this displacement will be of such magnitude as to require a time-consuming re-emplacement of the baseplate and a complete resighting of the gun. On the other hand, if the canted carriage was rigidly supported by the baseplate during the firing of the gun, the possibility of actual displacement would be greatly reduced. However, it is readily apparent that any rigid support of the carriage will certainly interfere with the required rise and fall of the rollers during the travel thereof over uneven terrain.

Accordingly, it is an object of this invention to provide a hydraulic linkage between the stationary baseplate and the carriage of a large caliber gun which will be capable of stabilizing such carriage against displacement by the recoil and counterrecoil forces imparted thereto during operation.

Another object of the present invention is to provide a hydraulic linkage as aforesaid, which will not interfere with the relative movement required between the gun carriage and the stationary baseplate whenever the carriage is being traversed over uneven terrain to bring the gun into firing alignment with a selected target.

It is a further object of this invention to provide a hydraulic piston and cylinder unit which will serve as a rigid link between a pivotal gun carriage and a stationary baseplate whenever the rate at which the unit is being loaded by the carriage exceeds a given value.

## SUMMARY OF THE INVENTION

It has been found that the foregoing objects can best be attained by a hydraulic unit in which a cylinder filled with hydraulic oil is arranged to slidably receive the enlarged head of a fixed piston. A poppet valve is slidably housed in the piston head and is arranged to be normally spring-biased to an open position. As the cylinder is reciprocated relative to the piston, the oil therein is forced through a restricted orifice in one side of the piston head into the area containing the poppet valve and then out through the opposite side of the piston head. However, when the cylinder is actuated at a velocity in excess of the maximum oil flow permitted by the restricted orifice, the resulting pressure differential causes the poppet valve to overcome the bias of the spring and move into position to completely close the restricted orifice. Once the flow of oil through the piston head is terminated, further movement of the cylinder is halted whereupon the unit becomes a rigid link in the structure in which it is located. When the oil pressure on the poppet valve drops below the force of the spring compressed thereby, the latter returns the valve to the open position thereof whereupon the cylinder can once again be actuated in either direction relative to the piston. The size of the restricted orifice and the bias of the poppet valve spring can be designed to permit a buffered movement of the cylinder relative to the piston as long as the loading applied thereto does not exceed a given rate.



## BRIEF DESCRIPTION OF THE DRAWINGS

The exact nature of the invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawings wherein:

FIG. 1 is a side view of a large caliber gun with a traversing carriage which is rotatably mounted on a fixed baseplate and is provided with a self-locking hydraulic linkage at each rear corner thereof;

FIG. 2 is a rear view of the gun showing the change in the relative positions of the hydraulic linkages when the carriage is being traversed over uneven terrain;

FIG. 3 is a sectional view taken along line 3—3 in FIG. 2 on an enlarged scale to show the interior structure of the hydraulic linkage;

FIG. 4 is a sectional view taken along line 4—4 in FIG. 3 to show the structure of the poppet valve assembly in the upper end of the piston head with the valve biased to the fully open position thereof;

FIG. 5 is a sectional view taken along line 5—5 in FIG. 4 to show the passageway for the flow of oil through the piston head; and

FIG. 6 is a view similar to that of FIG. 5 but showing the poppet valve in the fully closed position thereof.

## DESCRIPTION OF A PREFERRED EMBODIMENT

The self-locking hydraulic linkages of the present invention can be advantageously utilized in any structure wherein a movable member must be normally reciprocal relative to a fixed member and yet resist further movement whenever the velocity imparted to the movable member exceeds a predetermined amount. However, in order to emphasize the desirability of these hydraulic linkages, the structure and function thereof will be described in connection with a large caliber gun such as a howitzer of the type which must be towed from one location to another. Accordingly, referring more particularly to the drawings wherein similar reference characters have been employed to designate corresponding parts throughout, the howitzer shown in FIG. 1 essentially comprises a gun tube **12** slidably supported on a cradle **14** which is, in turn, pivotally secured at the rear end thereof to the corresponding end of a carriage **16**. In order to permit a full 360°-traverse of carriage **16**, the rearward portion thereof is provided with a depending ball **18** arranged to be rotatably seated in a mating socket **20** centrally located in a circular baseplate **22** fixedly emplaced on the ground identified by numeral **25**. Carriage **16** is provided with a pair of wheels **23** which can be raised during emplacement of the gun and lowered when towing is to be resumed. A pair of spaced rollers **24** are provided at the forward end of carriage **16** with each roller arranged to rotate about an axis parallel to the longitudinal axis of carriage **16**. Thus, when carriage wheels **23** are raised, rollers **24** are brought into contact with the ground to support carriage **16** for traverse movement about socket **20** in baseplate **22**.

In the event the terrain over which rollers **24** must pass during the traverse of the gun is rough or not level, the arrangement of ball **18** and socket **20** permits carriage **16** to pivot in a vertical plane relative to baseplate **22** or to cant in a lateral plane as best shown in FIG. **2**. However, in order to stabilize the gun when fired with carriage **16** in such pivoted or canted position, the linkage mechanism of the present invention is vertically installed in each rear corner of carriage **16**. Linkage

mechanism is essentially a dash pot comprising a stationary piston **26** and a movable cylinder **28** filled with a suitable hydraulic fluid such as a relatively light weight oil. Piston **26** is formed with an elongated rod **30** terminating in a ball **32** at one end thereof in rotatable engagement with a shoe **34** having a planar underside for slidable contact with a circular rail **36** on baseplate **22**. Retention of ball **32** in shoe **34** is provided by a pair of plate members **38** fitted against the exterior periphery of ball **32** and secured to shoe **34** by suitable screws **40**.

The opposite end of piston rod **30** terminates in an enlarged cylindrical head **42** surrounded by a sealing ring **44**. Extending upwardly from the top of piston head **42** is a rectangular housing **46** located so that one of the shorter sides thereof is closer to the exterior periphery of piston head **42** than the remaing three sides. The other and opposite shorter side of housing **46** is preferably of semicylindrical contour as indicated at **48** in FIG. **4** to minimize the size thereof. Housing **46** is vertically bored as indicated at **50** on the same center as that utilized to form semicylindrical contour **48** and such bore extends through piston head **42** into piston rod **30** in concentric relation to the exterior periphery thereof.

Cylinder **28** includes a hollow cylindrical inner member **52** arranged to fit over piston head **42** in slidable engagement therewith. The upper end of member **52** is seated against an annular shoulder **54** formed within the interior of a hollow cylindrical outer member **56**. Members **52** and **56** are joined in these relative positions by a stepped pin **58** disposed in axial alignment with piston rod **30**. The upper and smaller diameter portion **60** of pin **58** extends through the upper end walls of members **52** and **56** to terminate in an exposed threaded end **62** arranged to receive a locking nut **64**. The lower and larger diameter portion **66** of pin **58** extends downwardly into the interior of bore **50** to act as a guide for a spring, as will hereinafter be shown, without interfering with the required relative movement between cylinder **28** and piston **26**.

The interior diameter of outer member **56** is enlarged from a point just below annular shoulder **54** therein to a point just above the lower end of inner member **52** to provide a storage area **70** between members **52** and **56**. A plurality of ports **72** are formed in the lower end of inner member **52** to provide communication between the interior thereof and storage area **70**. An annular disc **74** is installed within the lower end of outer member **56** over piston rod **30** to provide a closure for cylinder **28** and a retainer for inner member **52** and is retained in place by an exteriorily threaded bushing **76** screwed into a correspondingly threaded section **78** at the lower end of outer member **56** and locked in place by a transverse pin **80**. Closure disc **74** includes suitable seals **82** in the exterior and interior peripheries thereof to prevent any leakage of oil from cylinder **28**. The bottom of bushing **76** is flanged, as indicated at **84**, to provide a mounting surface for a plurality of bolts **86** which serve to fasten cylinder **28** to the underside of carriage **16**.

An oil filler hole **88** is provided in the top of outer cylindrical member **56** and is arranged to be closed by a removable plug **90**. In addition, the exterior periphery at the top of inner member **52** is formed with a plurality of spaced beveled grooves **92** which bypass annular shoulder **54** and communicate with storage area **70**. Thus, when cylinder **28** is fully depressed relative to piston **26** and oil is introduced into outer member **56** through filler hole **88**, it will flow down through grooves **92** into storage area **70** and then through ports **72** up into inner member **52** behind piston head **42**. The introduction of oil into the upper space between members **52** and **56** is preferably accomplished after nut **64** is loosened on stepped pin **58** to permit the escape of any air trapped in either or both members **52** and **56**.

Extending transversely into the side of rectangular housing **46** is a cylindrical chamber **94** fully open at one end thereof and closed at the opposite end thereof except for a funnel-shaped orifice **96** therethrough. A poppet valve **98** of shorter length than chamber **94** is slidably retained therein by a split ring **100** releasably seated within a circumferential groove **102** adjacent the open end of chamber **94**. Valve **98** is formed by a piston **104** with a stem **106** projecting centrally fron one face thereof and is disposed within chamber **94** with stem **106** facing orifice **96**. A helical coil spring **108** surrounds stem **106** and is seated between valve piston **104** and the endwall within chamber **94** to normally retain valve **98** in an open position in which orifice **96** is unblocked. As best shown in FIGS. **5** and **6**, an oil passage **110** is angularly provided through piston head **42** in communication with the interior of chamber **94** in housing **46**.

As previously explained, the traverse movement of carriage **16** over uneven terrain causes the latter to pivot and cant relative to baseplate **22**. Since the linkage mechanisms are installed therein so that each cylinder **28** is fixed in the underside of carriage **16** while each piston **26** contacts rail **36** on baseplate **22**, the various movements of carriage **16** are translated into corresponding movement of cylinder **28** relative to piston **26**. As cylinder **28** is forced downwardly, the oil above piston head **42** is forced through orifice **96** into chamber **94** and out through inclined passage **110** into the reduced pressure area of inner member **52** below piston head **42**. Since the diameter of piston rod **26** is larger than portion **66** of pin **58**, the volume below piston head **42** will increase at a slower rate than the corresponding decrease in the volume thereabove. As a result, the excess oil will be forced upwardly through ports **72** into area **70** for temporary storage therein. During the upward or lifting movement of each rear corner of carriage **16**, the flow of oil through piston head **42** is reversed.

However, when the gun is fired with carriage **16** in a pivoted or canted position relative to baseplate **22**, it is essential that each piston and cylinder arrangement be converted to a rigid link capable of preventing the recoil forces from imparting further movement to carriage **16**. This is accomplished by limiting the size of orifice **96** in housing **46** below that required to fully accommodate the rapid flow of oil produced by the initial movement imparted to cylinder **28** by the recoil forces on carriage **16**. Such restriction in the flow of oil creates a pressure proportional to the square of the velocity of the movement imparted to cylinder **28**. As a result, poppet valve **98** is subjected to a differential pressure capable of overcoming the resistance of spring **108** and moving valve stem **106** to completely block orifice **96** against the flow of oil therethrough. The closing of orifice **96** creates an even greater pressure differential which will maintain valve **98** in the closed position thereof until the load imparted to cylinder **28** is reduced to the point at which the pressure differential will permit spring **108** to return poppet valve **98** to the open position thereof.

In the event baseplate **22** were to be sufficiently displaced during the firing of the gun to leave a gap between rail **36** and shoe **34** at the end of piston **26** upon the return of carriage **16** to the position occupied immediately prior to the firing of the gun, the weight of piston **26** will eventually return shoe **34** into contact with rail **36**. However, in order to reduce the interval between successive firings of the gun, the restoration of each linkage mechanism to the prefired position thereof can be expedited by providing a compression spring **112** to surround the larger diameter portion **66** of stepped pin **58** in abutment with the upper endwall surface within inner member **52** and of sufficient length to bottom in bore **50**. Spring **112** acts to resist telescoping movement between cylinder **28** and piston **26** and to assist relative movement therebetween in the opposite direction. The restoration of piston **26** into contact with rail **36** can be even further expedited by the provision of conventional ball check valves **114** in piston head **42** on each side of rectangular housing **46** thereon.

Thus, there is here provided a unique hydraulic linkage which can be readily incorporated into the underside of a gun carriage and provide a self-locking action which will stabilize the carriage during the firing of the gun regardless of the extent to which the carriage is tilted or canted relative to baseplate **22** at the instant of firing. Such desirable stabiliza-

tion of the gun carriage is achieved without interference with the required ability thereof to pivot and cant relative to a stationary baseplate during traverse over uneven terrain. Furthermore, the self-locking function of the hydraulic unit is simple and reliable and can be readily adjusted to positively differentiate between the rate of loading involved in traverse of the carriage and that imparted thereto during actual firing of the gun.

Although but a single, preferred embodiment of the present invention is shown and described herein, it will also become obvious to persons skilled in the art that other forms thereof, as well as changes in the particular form described, are possible within the spirit and scope of the present invention. Therefore, it is desired that the present invention shall not be limited except insofar as it is necessary by the prior art and by the spirit of the appended claims.

What is claimed is:

1. A self-locking hydraulic piston and cylinder arrangement comprising,

an enlarged head at one end of said piston in slidable engagement with the interior of said cylinder,

passage means through said piston head to accommodate the flow of hydraulic fluid displaced by movement of said cylinder relative to said piston, said means including an opening traversing said piston head in communication with a valve chamber therein having one end open and a funnel-shaped orifice in the opposite end thereof,

a poppet valve slidably disposed within said chamber with one end thereof adjacent said open end of said chamber for full exposure to the hydraulic fluid, and

a stem projecting from the other end of said poppet valve for closing said funnel-shaped orifice in response to a predetermined increase in the pressure of the hydraulic fluid surrounding said valve chamber.

2. A self-locking dash pot unit for linking a movable member to a stationary member comprising,

a cylinder fixedly secured to one of said members,

a piston having an elongated rod with one end thereof in abutment with the other one of said members and an enlarged head at the opposite end of said rod disposed for slidable retention in said cylinder,

passage means through said piston head to provide for the flow of hydraulic fluid displaced during movement of said cylinder relative to said piston,

a poppet valve laterally disposed in said piston head for slidable movement into and out of blocking association with said passage means and with one end thereof fully exposed to hydraulic fluid within said cylinder on one side of said piston, and

a spring for normally biasing said poppet valve to an open position in said passage means and being responsive to a fluid pressure in excess of the flow capacity of said passage means whereby the resulting differential pressure on said poppet valve overcomes the bias of said spring and causes said valve to close said passage means thereby halting further movement of said cylinder relative to said piston and providing a rigid link between said movable and stationary members.

3. The invention defined in claim 2 including a ball check valve in said piston head for increasing the flow of hydraulic fluid therethrough in response to separation of one member from the other member.

4. The invention defined in claim 2 including a compression spring for biasing said elongated rod on said piston into abutment with said other member.

5. The invention defined in claim 2 wherein said piston head includes a transverse chamber for slidably seating said poppet valve and wherein said passage means comprises a funnel-shaped orifice leading from one side of said piston into one end of said poppet valve chamber and an opening extending from said chamber to the opposite side of said piston in the vicinity of said piston rod.

6. The invention defined in claim 5 wherein said poppet valve includes a projecting stem in axial alignment with said funnel-shaped orifice which serves to block the passage of hydraulic fluid therethrough in response to the differential pressure acting upon said poppet valve.

7. In a large caliber gun having a carriage terminating in rollers at one end thereof and provided at the opposite end thereof with a ball engageable in a socket in the center of a stationary baseplate whereby the carriage can be canted to permit the traverse thereof over uneven terrain into firing alignment with a selected target, the improvement of a pair of self-locking hydraulic units disposed in spaced apart relation between the rear corners of the carriage so as to permit the canting thereof during the traverse of the gun and yet provide a rigid link between the carriage and the baseplate under the recoil forces imparted thereto upon the firing of the gun, each of said units comprising,

cylinder means filled with hydraulic fluid and fixedly secured to the underside of the carriage,

a piston having an enlarged head in slidable engagement with said cylinder means and an elongated rod extending outwardly of said cylinder into abutment with the stationary baseplate,

passage means through said piston head to accommodate flow of hydraulic fluid from one side of said piston head to the other side thereof, said fluid being displaced in response to the movement imparted to said cylinder means by the canting of the carriage,

valve means slidably disposed in said piston head in direct communication with said passage means, and

spring means for biasing said valve means to a normally open position during the traverse of the carriage about the stationary baseplate, said spring means being responsive to fluid pressure in excess of the flow capacity of said passage means whereby said valve means will close said passage means and prevent further movement of said cylinder means relative to said piston thereby providing a rigid link between the carriage and the baseplate capable of resisting the recoil forces produced by the firing of the gun despite the difference in the relative positions of each of said hydraulic units due to the canting of the carriage.

8. The invention defined in claim 7 wherein said cylinder means comprises,

a hollow outer member having an interior annular shoulder,

a hollow inner member having a plurality of exit ports at one end thereof and a plurality of beveled grooves at the opposite end thereof, said inner member being fixedly secured within said outer member with said grooves adjacent said annular shoulder therein and being spaced from the interior periphery thereof to provide a storage area in communication with said exit ports to receive the hydraulic fluid displaced by said rod portion of said piston when said cylinder is actuated toward the stationary baseplate, and

closure means secured to said outer member end with said exit ports to retain the hydraulic fluid in said cylinder means.

9. The invention defined in claim 7 wherein said enlarged head of said piston is provided with a projecting rectangular housing containing a transverse chamber open at one end and closed at the opposite end thereof and a bore adjacent said chamber extending axially into said elongated rod portion of said piston and wherein a compression spring is seated between an endwall of said inner member and the endwall within said piston rod bore to bias said piston and said cylinder in opposite directions to maintain said piston in abutment with the stationary baseplate.

10. The invention defined in claim 9 wherein said passage means is provided by a funnel-shaped orifice in said closed end of said chamber and an opening extending from the side of said chamber through said piston head into communication with the area surrounding said piston rod portion.

11. The invention defined in claim 9 wherein said valve means comprises, a poppet valve slidably disposed in said chamber having a stem projecting axially from said valve toward said funnel-shaped orifice, and a split ring in said open end of said chamber for retaining said poppet valve therein against the bias imparted thereto by said spring means.

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