July 16, 1963 H. E. MERRITT ET AL Re. 25,415

HYDRAULIC POWER UNIT AND CONTROL SYSTEM FOR TRACTORS

Original Filed Aug. 28, 1958 3 Sheets-Sheet 1

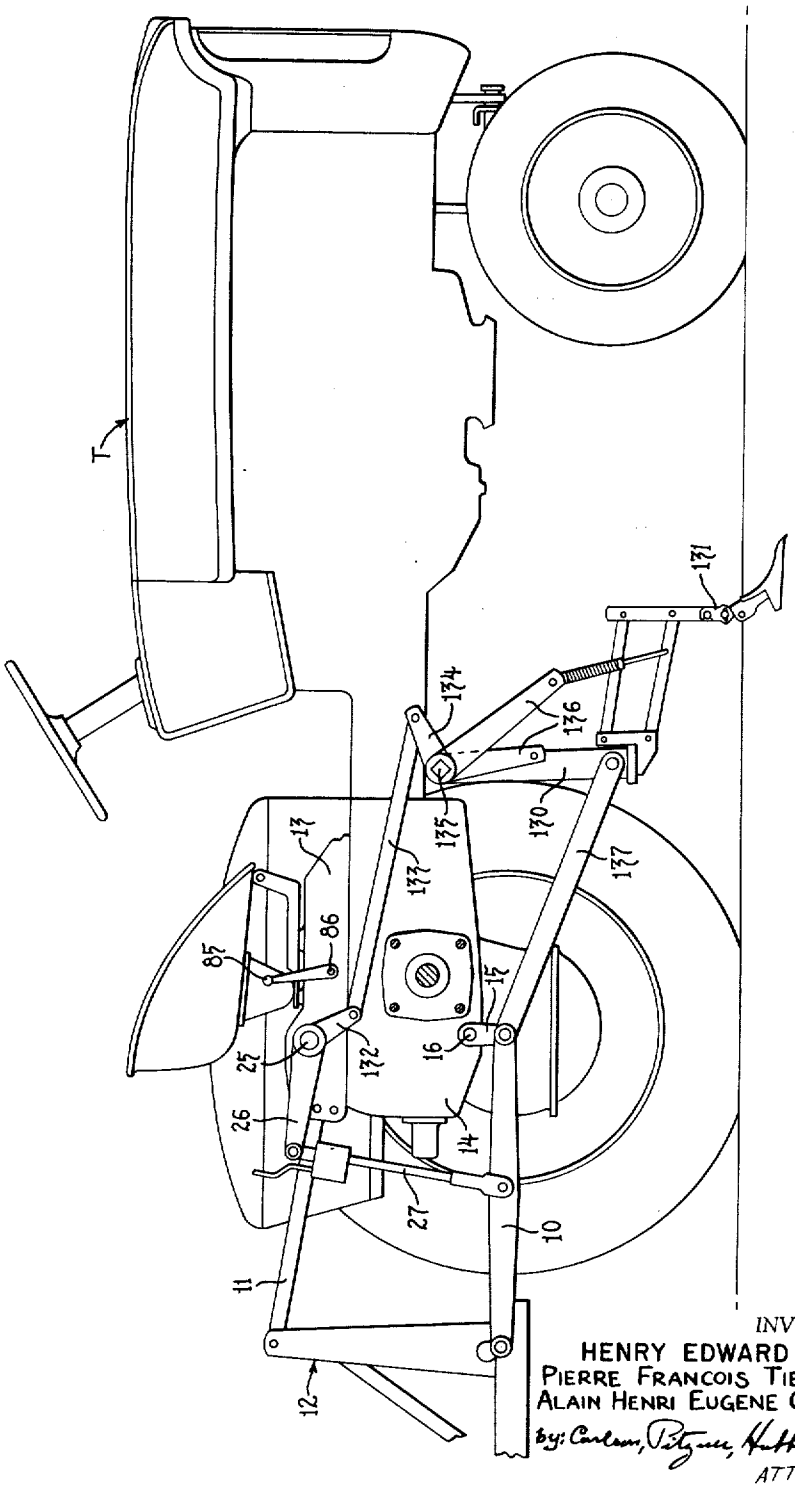


Fig. 1

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Original Filed Aug. 28, 1958 3 Sheets-Sheet 2

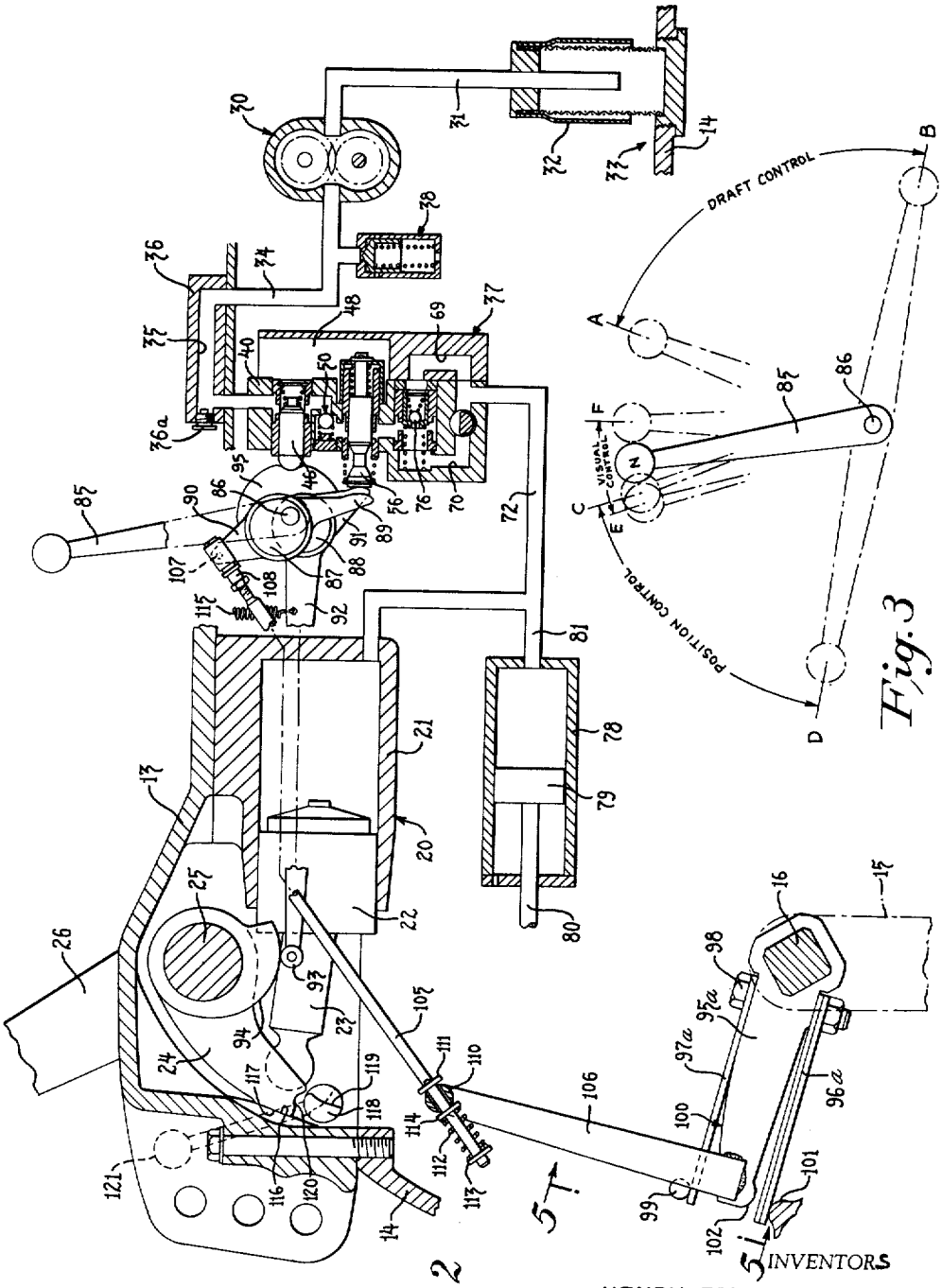


Fig. 3

Fig. 2

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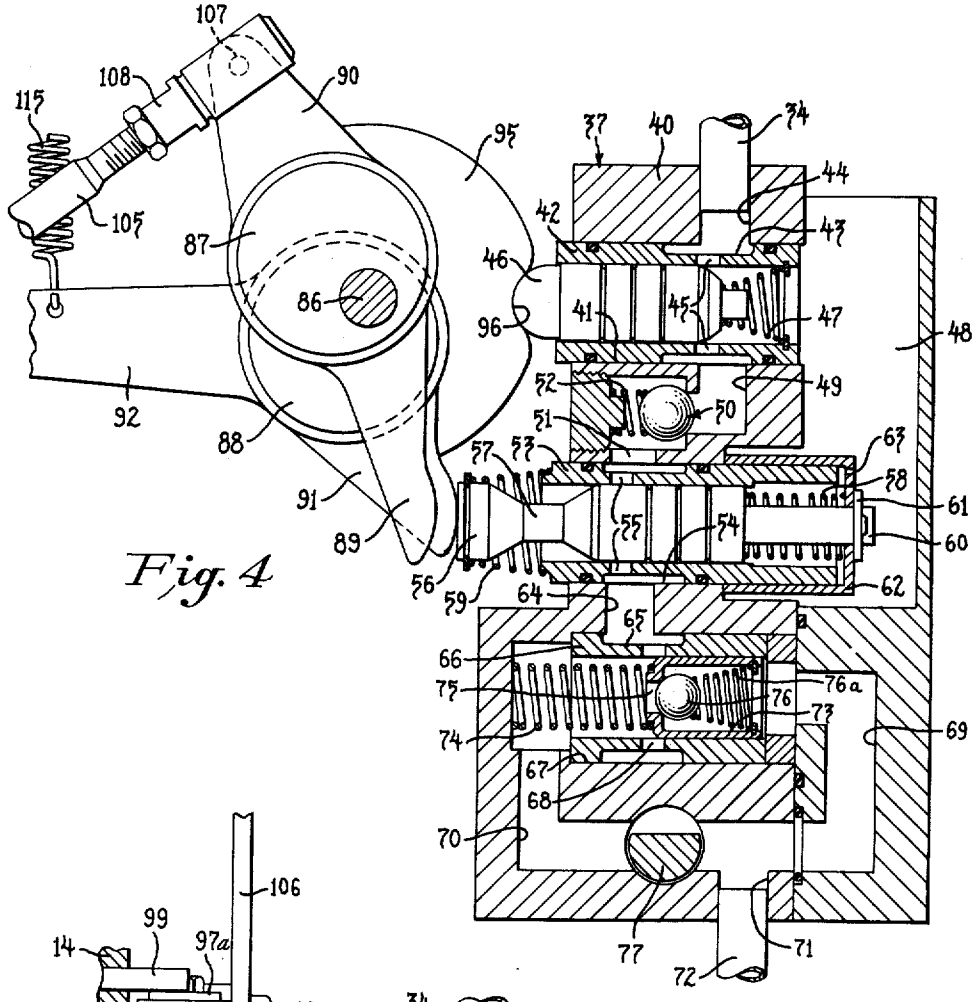


Fig. 4

Fig. 5

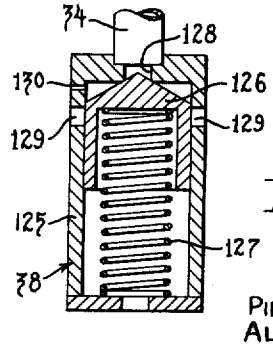


Fig. 6

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HYDRAULIC POWER UNIT AND CONTROL SYSTEM FOR TRACTORS

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Claims priority, application Great Britain Sept. 3, 1957
13 Claims. (Cl. 172—9)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

The invention relates generally to tractors of the type equipped with a power elevatable hitch linkage and more particularly, to an improved hydraulically operated power unit and control system for use in such tractors.

One object of the invention is to provide a hydraulic system of the above general character affording what is commonly known as automatic draft control and automatic position control as well as full visual control of auxiliaries in which manual regulation of all three types of control as well as selection between those different types is effected through the medium of a single manual operator or control tower.

Another object is to provide an improved valve assembly for use in tractor hydraulic systems.

Another object is to provide improved means for selecting the type of control under which the system is to operate.

Another object is to provide improved spring arrangement for balancing tension and compressive forces imposed on the tractor by the hitch linkage.

Still another object is to provide improved means for unloading and reloading the pump supplying pressure fluid to the hydraulic system.

A further object is to provide improved means for regulating the movements of the control valve so as to reduce shock loads on the hitch linkage regardless of the type of control in use.

A still further object is to provide improved means for automatically adapting the hydraulic system for efficient operation with implements of different weights.

It is also an object of the invention to provide a tractor hydraulic system which is simple in construction, efficient and dependable in operation and which is particularly characterized by its versatility and wide range of adaptability.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings in which:

FIGURE 1 is a side elevational view of a tractor equipped with a hydraulic system embodying the features of the invention, the drive wheel on the near side of the tractor being removed to show details of the implement hitch linkage and associated parts.

FIG. 2 is a partly diagrammatic sectional view through the center housing of the tractor showing details of the hydraulic system.

FIG. 3 is a diagrammatic view of the manual control lever showing its operating ranges for different types of control.

FIG. 4 is a sectional view of the control valve assembly shown in FIG. 2 but on a larger scale.

FIG. 5 is a fragmentary sectional view taken on a plane substantially on the line 5—5 of FIG. 2.

FIG. 6 is an enlarged sectional view of the unloading valve shown in FIG. 2.

While a single preferred embodiment of the invention has been shown and will be described herein, this is not intended to limit the invention to the particular form illustrated. On the contrary, the intention is to cover all modifications, adaptations and alternative constructions falling within the spirit and scope of the invention as more broadly or generally characterized in the appended claims.

GENERAL

By way of illustration, the invention has been shown as incorporated in a tractor T having a trailing three element implement hitch linkage including a pair of laterally spaced lower or draft links **10** and a top link **11**. The links are pivoted on the tractor to swing vertically for raising or lowering an implement **12** connected in the conventional manner to the trailing ends of the respective links. As shown in FIG. 1, the top link is pivoted at its forward end on the upper part of the tractor body, in this instance, to a cover plate **13** which closes the upper end of the tractor center housing **14**. Draft links **10**, in this instance, are pivoted to depending arms **15** carried by a transverse rock shaft **16** journalled in the lower portion of the housing. This latter connection is utilized to transmit draft forces for control of the hydraulic system as will appear presently.

POWER UNIT

Raising and lowering of the draft links **10** and attached implement is effected by a power unit **20** enclosed in the center housing **14** of the tractor as shown in FIG. 2. The power unit is preferably hydraulically operated and, in the exemplary embodiment, comprises a cylinder **21** supported on the cover plate **13** with its open end facing rearwardly. A piston **22** slidingly fitted in the cylinder **21** is operatively connected by a piston rod **23** with a crank arm **24** rigidly fixed on a cross shaft **25** journalled in the center housing cover plate **13**.

As is customary in tractors of the general type under discussion, the shaft **25** projects at opposite sides of the housing and carries a crank arm **26** (FIG. 1) at each end connected by a drop link **27** with the draft link at the same side of the tractor. The arrangement is such that when pressure fluid is supplied to the cylinder **21** the piston **22** is forced rearwardly to rock the shaft **25** clockwise and thus swing the hitch linkage and the attached implement upwardly. When fluid is permitted to escape from the cylinder, the weight of the hitch linkage and the load which it carries forces the piston inwardly as the linkage descends.

Pressure fluid for operating the power unit **20** is supplied by a pump **30** which may be driven continuously from the tractor engine in well-known manner. The particular pump shown is a gear pump connected to draw fluid such as oil through an inlet conduit **31** and filter **32** from a sump or reservoir **33** provided in the lower portion of the center housing **14**.

Pressure fluid discharged by the pump **30** is carried by a conduit **34** and passage **35** in a bridge member **36** to a valve assembly **37**. The bridge member **36** provides externally accessible ports for connecting the supply conduit to auxiliary equipment when required, the ports otherwise being closed by plugs **36**a. A relief or overload release valve **38** connected to the conduit **34** opens automatically when the pressure in the system exceeds a predetermined value and diverts the fluid from the pump to the sump to prevent overloading of the hydraulic system. This valve also serves to unload the pump **30** when a supply of pressure fluid is not required.

CONTROL VALVE ASSEMBLY

The valve assembly **37** includes in a single, compact

unit a plurality of valves by which the various functions of the hydraulic system are controlled including the delivery of pressure fluid to and exhaust of fluid from the power unit **20**. As shown in FIG. 4, the valve assembly **37** comprises a casing **40** formed with a series of parallel bores and connecting passages for accommodating the various valve elements of the assembly. Thus, adjacent the upper end of the casing a bore **41** accommodates a by-pass valve comprising a sleeve **42** having an external groove defining an annular chamber **43** communicating with a port **44** into which the supply conduit **34** delivers pressure fluid. Radial ports **45** of the sleeve are controlled by an axially slidable plunger **46** yieldably urged by a spring **47** toward the open position in which it is shown in the drawing. When the ports **45** are open, fluid passes from the chamber **43** to the interior of the sleeve **42** from which it is discharged into an auxiliary reservoir **48** formed in the valve casing. Fluid is thus released from the system at low pressure and the pump is unloaded to reduce the power demands on the tractor engine. Excess fluid discharged into the reservoir **48** is spilled over into the sump **33**.

The plunger **46** is adapted to be shifted to closed position by manually operable control means described hereinafter. When in the closed position ports **45** are covered by the plunger and exhaust of fluid to the auxiliary reservoir is interrupted. Pressure fluid then flows from the chamber **43** through a passage **49** in the valve casing and through a check valve **50** to a chamber **51** of the main control valve. Check valve **50** as shown is a ball type valve urged by a spring **52** to a position to prevent reverse flow through the passage **49**.

The chamber **51** of the main control valve is defined by an external circumferential groove in a sleeve **53** seated in a bore **54** in the valve casing. Radial ports **55** in the sleeve provide communication between the chamber **51** and the interior of the sleeve which is open at one end to the sump **33**. Opening and closing of the ports **55** is controlled by a plunger **56** slidable in the sleeve, the plunger having a section **57** of reduced diameter through which the ports **55** may be vented to the sump.

In the preferred form shown, the valve plunger **56** is urged toward a closed position by a pair of springs **58** and **59** interposed between opposite ends of the plunger and the sleeve. Control means to be described hereinafter is provided for shifting the plunger toward open position. Movements of the plunger at either direction are restrained or damped by dashpot means associated with the plunger. For this purpose the end portion **60** of the plunger remote from the open end of the sleeve is reduced in diameter and extended to project beyond the other end of the sleeve.

Mounted on the projecting end of the plunger and retained in place by a stop washer **61** pinned to the plunger is a cup-shaped end cap **62** adapted to telescope over the sleeve. The end cap and sleeve thus define a chamber adapted to expand upon movement of the plunger in one direction and to contract upon movement of the plunger in the opposite direction. As will be seen by reference to the drawings, the end cap is disposed within the auxiliary reservoir **48** so that it is completely submerged in the oil collected in the reservoir. Accordingly, fluid is alternately drawn into and expelled from the chamber through a hole **63** in the end of the cap as the plunger is shifted in one direction or the other. The hole **63** is dimensioned to restrict flow sufficiently to restrain the plunger against too rapid movement in either direction and thus reduce shock loads on the hydraulic system.

With the valve plunger **56** in closed position exhaust of fluid to the sump is interrupted and pressurized fluid in the chamber **51** is directed through a restrictor valve to the hydraulic unit **20**. More particularly, the fluid flows from the chamber **51** through a passage **64** in the casing to an annular chamber **65** defined by a sleeve **66** seated in a bore **67** in the casing. Radial ports **68** permit communication between the chamber **65** and the interior of the sleeve which opens at opposite ends to a pair of passages **69** and **70**. These passages jointly communicate with a port **71** connected by a conduit **72** with the closed end of the cylinder **21** of the power unit as shown in FIG. 1.

Slidable within the sleeve **66** is a cup-shaped valve member **73** normally held out of blocking relation to the port **68** by a spring **74**. The valve member has a central passage **75** in its end wall closed against fluid flow in one direction by a check valve comprising a ball **76** urged toward the passage by a spring **76a**. The check valve is adapted to open and permit substantially unrestricted fluid flow to the power unit when the main control valve is set to direct fluid to the power unit for raising the hitch linkage. Upon movement of the control valve to lowering position, check valve **76** closes and fluid exhausted from the power unit is directed through the branch passage **70**.

It has been found that selected working depths can be maintained with greater accuracy and with less hunting by restrictively controlling the rate of descent of the implement. Moreover, such control insures sufficient weight transfer from the implement to the tractor to provide adaquate traction as the implement is being pulled into the ground. Control of the rate of descent or the drop rate of the hitch linkage and implement is provided in the present instance by an adjustable metering valve **77** interposed in the exhaust passage **70**.

While the setting of the valve **77** determines the drop rate of the hitch linkage, the restrictor valve with which it is associated acts automatically to keep the drop rate constant when implements of different weights are mounted on the hitch linkage. Thus fluid discharge from the cylinder **21** in the lowering of the hitch passes through the metering valve **77** and the ports **68** of the restrictor valve on its way to the sump through the control valve ports **55**. Valve member **73** of the resistor valve is thus subject to a pressure differential tending to move it to the left or into position to partially close the ports **68**. More particularly, the right end of the valve member is subject to the full ram pressure applied through the fluid in the passage **69**. The left end of the valve member, on the other hand, is subject to the pressure in the passage **70** which is reduced by the action of the metering valve. The valve member **73** accordingly assumes a position effective to partially close the ports **68** and thus maintain a uniform pressure drop through the valve. Any increase in the drop rate is reflected by a corresponding decrease in pressure in the passage **70** and valve member **73** is automatically advanced to throttle fluid flow through the ports **68** and thus restore the pressure balance.

The valve assembly **37** may also be utilized to control the fluid supply to an auxiliarly hydraulic actuator such as that shown in FIG. 2 as comprising a cylinder **78** fitted with a working piston **79**. In the exemplary actuator the piston is operatively connected with an implement part or other element to be moved by a piston rod **80**. Pressure fluid is supplied to and exhausted from the cylinder **78** by way of a conduit **81** suitably connected with the fluid supply conduit **72** for the power unit.

MANUAL AND AUTOMATIC CONTROL

Actuation of the valves of the assembly **37** is effected manually by the driver of the tractor and automatically under control of selectively available draft responsive and position responsive means. Both automatic controls operate in conjunction with the manual control, the draft responsive means acting to maintain the draft load to which the implement subjects the tractor at a manually predetermined constant magnitude. The draft load is the force resulting from the reaction of the ground against the implement as the latter is drawn forwardly by the

tractor. Accordingly, the case of a soil working implement such as a plow, maintenance of a constant draft load results in maintaining the implement at a more or less constant working depth under substantially uniform soil conditions. The position responsive means when selected for operation acts to shift the hitch linkage to and maintain it at a manually predetermined level relative to the tractor.

CONTROL SELECTION

Manual control selection between automatic draft and position control and regulation of the selected control is effected through the medium of a single hand lever **85**. The hand lever is fixed on the projecting end of a transverse rock shaft **86** journalled in the housing cover plate **13**. Preferably the lever is presented at the right side of the tractor in a position in which it is conveniently accessible to the tractor driver.

Fixed on the shaft **86** within the housing **14** are a pair of eccentrics **87** and **88**. Eccentric **87** rotatably supports a control lever having one arm **89** positioned for cooperation with the plunger **56** of the main control valve as shown in FIG. 4. The other arm **90** of the lever is connected with the draft responsive means as will appear presently. This lever is referred to hereinafter as the draft control lever.

Eccentric **88** rotatably supports a bell crank lever having an arm **91** positioned alongside the arm **89** for alternate cooperation with the control valve plunger **56**. The other arm **92** of the bell crank lever is extended rearwardly and provided with a follower **93** (FIG. 2) positioned to cooperate with a cam **94** on the lift shaft **25**. The cam is shaped to coordinate the position of the lever with the position of the hitch linkage in relation to the tractor.

Also fixed on the hand lever shaft **86** is a cam disc **95**. The cam disc is positioned to engage the projecting end of the by-pass valve plunger **46** as shown in FIG. 4. A notch **96** in the edge of the cam is located to receive the valve plunger when the hand lever **85** is set in the neutral position in which it is shown in full lines in FIG. 3. With the cam so positioned, spring **47** shifts the valve plunger to open position, thus by-passing the pressure fluid from the pump back to the sump. Upon movement of the hand lever in either direction from the neutral position, cam **95** shifts the valve plunger **46** to the right to close the by-pass ports **45** and thus initiate delivery of pressure fluid through the check valve **50** to the main control valve as before explained.

For carrying out its selecting and controlling functions, the hand lever **85** is adapted to be swung through three different ranges in an arc of approximately 180° as shown in FIG. 3. Thus, the lever may be swung forwardly in the arc A—B which is the draft control range and in this arc it acts jointly with the draft responsive means to regulate the draft load on the implement and thus determine the implement working depth. Similarly the lever may be swung rearwardly in the arc C—D which is the position control range and in that arc it acts jointly with the position control means or cam **94** to regulate the position of the hitch linkage relative to the tractor. Swinging of the lever through the intermediate arc E—F is utilized to control auxiliary assemblies described in detail later on.

The selecting action of the hand lever **85** is determined by the angular relationship of the eccentrics **87** and **88** to each other and to the hand lever. As shown in FIG. 4, the eccentrics are displaced from each other approximately 120° at opposite sides of and approximately equidistant from a plane through the axis of the shaft **86** normal to the hand lever. Accordingly, movement of the control lever into the draft control range A—B will shift the pivot axis of the draft control lever **89—90** forwardly or toward the valve assembly into cooperative relation with the control valve. At the same time, the pivot axis of the position control lever **91—92** is shifted rearwardly

to carry the lever to an inactive position. Movement of the hand lever rearwardly into the position control range C—D reverses the position of the control levers. More particularly, with the hand lever in the range C—D, control lever **91—92** is conditioned for operating the control valve plunger **56** and draft control lever **89—90** is shifted to inactive position.

DRAFT CONTROL

Selection of the draft control lever **89—90** for operation places the draft responsive means and hand lever **85** jointly in control of the main valve. The draft responsive means in the present instance is associated with the draft links **10** of the hitch linkage. As previously explained, the links are pivoted to the arms **15** depending from the rock shaft **16**. The draft on the implement attached to the hitch linkage accordingly tends to rotate the shaft **16** clockwise as viewed in FIG. 2. Compressive forces exerted through the draft links as, for example, when the links and attached implement are raised to a transport position, tend to rock the shaft **16** in the opposite direction.

Novel means is provided for balancing the forces transmitted through the draft links, that is for yieldably resisting rotation of the shaft **16** in either direction by such forces. More particularly, a simple yet effective spring arrangement is associated with the shaft in a manner such that its displacement is proportional to the force imposed on the draft links.

Referring more particularly to FIG. 2, the balancing spring arrangement in its preferred form includes a lever **95a** nonrotatably mounted on the shaft **16** and projecting radially and generally horizontally therefrom. Disposed on opposite sides of the lever are a pair of leaf springs **96a** and **97a** each anchored at one end to the lever adjacent the shaft **16** as by a bolt **98**. The latter spring which overlies the upper face of the lever **95a** has its free end in engagement with the fixed stop **99** positioned to enable it to resist clockwise rotation of the shaft **16**.

Preferably, the upper face of the lever **95a** is formed with a cam profile **100** effective to automatically decrease the effective length of the spring **97a** as the shaft and lever are turned in a clockwise direction. Accordingly, the resistance offered by the spring to the rotation of the shaft is progressively increased as the draft load on the hitch linkage increases and tends to rock the shaft through a greater arc. This progressive increase in resistance is highly advantageous in maintaining proper sensitivity of the draft responsive means.

The lower spring **96a** which, in this instance, is laminated, has its free end in engagement with a fixed stop **101** positioned to enable the spring to resist anticlockwise rotation of the shaft **16**. Such rotation occurs from a compressive force exerted through the draft links **10** which may occur when an implement is carried in transport position. Compressive forces may also be experienced with heavy implements, as, for example, when the moment thereon due to the draft force is less than the moment imposed by the overhanging implement weight. Spring **96a** thus permits the draft responsive means to function effectively with heavy implements. In addition, it serves as a cushion for implements when in transport position. A projection **102** adjacent the end of the lever **95a** engages the spring **96a** in the vicinitiy of the fixed stop **101** to define the limit position to which the hitch linkage and associated parts may be shifted in a forward or compressive movement of the draft links.

It will be evident from the above that the draft forces acting on the implement, within practical limits, are reflected by corresponding movements of the lever **95a**. Such movements are transmitted from that lever to the draft control lever **89—90** by a linkage including a rod **105** and arm **106**. The arm is welded or otherwise rigidly attached to the lever **95a** adjacent its free end to

define therewith an L-shaped lever assembly. At its upper end the arm **106** is pivotally connected to an end of the rod **105** which has its other end pivotally connected as at **107** (FIG. 4) to the arm **90** of the control lever. The latter connection includes a fitting **108** threaded on the rod and affords adjustment of the effective length of the rod.

The pivotal connection between the rod **105** and the arm **106** also constitutes a one-way lost motion connection. As shown in FIG. 2, this connection includes a stud **110** pivotally mounted at the end of the arm **106** and formed with a diametrically disposed aperture dimensioned to slidably receive the rod **105**. An abutment **111** on the rod which may conveniently comprise a washer welded, pinned or otherwise secured to the rod by a stud **110** provides a positive coupling by which the movements of the arm **106** are transmitted to the rod in one direction.

Movements of the arm **106** in the opposite direction are transmitted to the rod **105** through the yieldable or lost motion connection. This connection includes a compression spring **112** interposed between an abutment or washer **113** rigidly fixed to the rod and a washer **114** slidably mounted on the rod adjacent the stud **110**.

It will be evident that signals indicating an increase in draft load are transmitted to the control lever **89—90** in a positive manner through the fixed abutment **111** and the rod **105**. If the draft increase signal is quicker than the valve plunger can follow the arm **89** is simply retracted from the plunger without damage to the parts involved. The plunger then follows at a rate determined by its associated damping means.

Movement of the arm **106** in the opposite direction as in the case of a draft decrease signal is transmitted to the rod **105** through the lost motion connection above described. Accordingly, if the signal is too quick or violent for the control valve to follow, the spring **112** is compressed against the washer **113** while the valve moves smoothly under the dashpot action of its associated damping means. This lost motion connection also permits rapid movement of the hand lever **85** through the draft control arc to the lowering position without damage to the mechanism.

To operate the tractor in draft control the driver simply swings the hand lever **85** forwardly from neutral position into the range A—B. In the initial movement of the hand lever, the by-pass valve plunger **46** is shifted to closed position and the draft control lever **89—90** is swung into operative position. Position control lever **91—92** is swung rearwardly to the inactive position. Assuming the hitch linkage to be in transport position, the main valve plunger **56** will be in its lefthand position closing ports **55** as the hand lever approaches the arc A—B.

If the hand lever **85** is now pushed down toward the bottom of the arc, that is, toward position B, control lever **89—90** will be rotated anticlockwise since its arm **90** is held stationary by the link **105** as the axis of the lever moves forwardly with the hand lever. Such rotation of the control lever shifts the valve plunger **56** to the right sufficiently to open the ports **55**, thereby diverting the fluid supplied by the pump to the sump. Cylinder **21** of the power unit is also vented to the sump allowing the piston **22** to retreat into the cylinder and lower the draft linkage and attached implement.

As the implement enters the ground it becomes subject to resistance and the draft forces imposed on the links **10** produce a proportional rotation on the shaft **16** against the force exerted by the balancing spring **97a**. Rotative movements of the shaft **16** are transmitted through the lever **95a**, arm **106** and rod **105** to the control lever **89—90** rocking the lever in a clockwise direction or away from the valve plunger **56** which is accordingly shifted toward the closed position by the associated springs.

It will be appreciated that the value of the draft load required to return the valve plunger to a balanced position is dependent on the distance the hand lever has been advanced in the arc A—B. In other words, the farther the hand lever is moved from the position A, the greater the initial displacment of the valve plunger **56** toward open position and the higher the draft load required to effect return of the plunger. In any case, the closing movement of the valve plunger proceeds with a gradual throttling of fluid flow through the ports **55** until the pressure prevailing in the system is just sufficient to sustain the implement at the desired working depth determined by the setting of the hand lever.

If the draft load increases beyond the value called for by the hand lever setting, further rotation of the shaft **16** rocks the control lever in a direction to permit further movement of the valve plunger **56** to the left. The additional throttling of the exhaust fluid allows pressure to build up in the system and the power unit imparts a lifting movement to the linkage. As the implement is raised, the draft load decreases and this is reflected by a corresponding clockwise rocking of the shaft **16**. Such movements imparted to the control lever **89—90** serve to reposition the valve plunger **56** to reestablish the balance between the pressure in the hydraulic system and the draft load.

Operation of the draft control mechanism proceeds in a reverse manner when the draft load on the implement decreases from the value set by the hand lever. When such a decrease occurs, the shaft **16** and control lever **89—90** act to shift the plunger **56** to the right thereby increasing the amount of fluid vented from the system and allowing the hitch linkage and implement to descend. As the implement penetrates the ground and the draft load correspondingly increases, the valve plunger is progressively shifted back until a balanced condition is attained and the implement is operating at the desired depth.

POSITION CONTROL

Swinging of the hand lever **85** rearwardly or into the arc C—D shifts the draft control lever **89—90** to inactive position and moves the position control lever **91—92** into operative relation to the valve plunger **56**. The hand lever is then conditioned to act jointly with the cam **94** in raising or lowering the hitch linkage into a selected position relative to the tractor and for maintaining it in such position.

As will be seen by reference to FIG. 2 of the drawings, the cam **94** which is mounted on and rotatable with the lift shaft **25**, is shaped so as to rock the lever **91—92** anticlockwise as the hitch links are raised. A spring **115** acting on the control lever maintains the follower **93** in engagement with the cam. Lowering of the hitch linkage and anticlockwise rotation of the shaft **25** permits the control lever to turn clockwise.

When the hitch linkage is in the elevated or transport position rearward swinging of the hand lever **85** into the arc C—D acts to carry the control lever forwardly and arm **91** engages the valve plunger **56** to shift it to the right to open the ports **55**. This vents fluid from the cylinder **21** of the power unit and allows the linkage to descend as before described. As the lift shaft rotates, cam **94** imparts a clockwise movement to the control lever swinging the arm **91** to the left and permitting the valve plunger **56** to follow in the same direction under the urging of its springs. Such movement continues until a hydraulic balance is attained effective to hold the linkage and attached implement in a position determined by the setting of the hand lever **85** within the arc C—D. In other words, the hitch linkage follows precisely the movements of the hand lever **85** and comes to rest in a position corresponding to that occupied by the hand lever in the position control range.

TRANSPORT POSITION LOCK

The valve **38** previously referred to protects the hydraulic system against excessive overload pressures and additionally provides a convenient means for unloading the pump **30** when an implement is carried in transport position. In accordance with the invention, the unloading of the pump under such conditions is made practical by the provision of novel means for mechanically locking the hitch linkage in transport position.

Transport position of the linkage is determined in this instance by a stop-pad **116** on the housing cover plate **13** positioned for engagement by a stop surface **117** on the crank arm **24** as shown in FIG. 2. Supported for rotation in the cover plate **13** is a locking pin **118** formed with a transverse slot or groove **119** in one side. When the pin is rocked to operated or locking position, the solid portion in back of the groove is presented in the path of an abutment **120** formed on the end of the crank arm **24**. The crank arm **24** and lift shaft **25** upon which it is mounted are thus positively blocked against movement in a direction to lower the hitch linkage.

To release the shaft for lowering the hitch linkage, the pin **118** is rotated until the slot occupies the position indicated in broken lines in FIG. 2. The slot then affords clearance for the abutment **120** so that the crank arm can swing down and lower the hitch linkage as previously described. A handle **121** on one end of the pin provides convenient means for manually rotating it between locking and release positions. In practice, a suitable detent or biasing spring is provided for maintaining the pin in set position.

OVERLOAD RELEASE AND PUMP UNLOADING

The mechanical blocking of the lift mechanism when the linkage is raised to transport position prevents further operation of the power unit **20** and consequently the hydraulic pressure in the system rises as the pump **30** continues to operate. This pressure rise is utilized to open the valve **38** and unload the pump in the same manner as when excessive pressure develops in the system from any other cause.

As shown in FIG. 6, valve **38** comprises a casing **125** having a slidable valve plunger **126** urged by a spring **127** to close a relatively small port **128** connecting with the supply conduit **34**. The valve plunger also slides over and closes a series of exhaust ports **129** in the casing. When the plunger is in the valve closing position. only a small area of its upper face is exposed to the pressure of the fluid at the port **128**. The spring **127** exerts sufficient force on the plunger to maintain it in closed position under normal operating pressure. A small bleed port **130** in the upper end of the casing prevents pressure from building up in the casing in the event of slight leakage around the plunger.

When the pressure in the system rises a predetermined amount above the normal operating pressure, the resistance of the spring is overcome and the plunger **126** is forced away from the port **128**. As the port is opened, the full area of the plunger is exposed to the pressure at the pump discharge and the plunger is therefore quickly shifted to the open position in which the ports **129** are either fully or partially uncovered. The fluid delivered by the pump **30** is exhausted through the ports **129** to the sump and the pressure in the system is accordingly reduced to a value such that the force exerted by the spring **127** is balanced by the pressure exerted against the full area of the valve plunger. Accordingly a minimum pressure is maintained in the system at all times, but this pressure is low enough so that the pump can continue in operation without excessive waste of power and without objectionable heating of the fluid.

The relief valve **38** may be reset to closed position by reducing the pressure in the system sufficiently to allow the spring **127** to return the plunger to closed position. Such pressure reduction can be effected quickly and conveniently by swinging the hand lever **85** to neutral position. Cam **95** is thus positioned to allow the by-pass valve plunger **46** to move into open position and the pump delivery is thus discharged to the sump at very low pressure.

CONTROL OF AUXILIARIES

Control of auxiliary actuators such as the cylinder and piston actuator **78—79** is effected by movement of the hand lever through its third operating range, that is, through the arc designated E—F in FIG. 3. The actuator shown in FIG. 2 is a one-way ram and introduction of pressure fluid into the right or closed end of the cylinder **81** acts to force the piston **79** and its load toward the left. The load is applied to the piston in a manner such that it tend to return the piston toward the closed end of the cylinder when fluid is permitted to exhaust therefrom. It will be understood that auxiliary actuators of the type illustrated may be mounted on the tractor or on an implement coupled to the tractor. It will also be understood that the tractor usually is provided with suitable fittings for quick and easy connection of such actuators.

With the hand lever **85** set in the neutral position in which it is shown in FIG. 3, the main control valve is closed and the by-pass valve is open. The latter valve accordingly diverts the pump discharge to the sump. The main power unit **20** and the auxiliary actuator are retained in the position to which they were previously operated by the check valve **50** which prevents exhaust of fluid from the respective cylinders. When the auxiliary actuator is to be operated alone, the hitch linkage may be mechanically locked in the raised or transport position as above explained.

If it is desired to operate the auxiliary actuator in a lifting direction, hand lever **85** is swung clockwise from the neutral position within the arc E—F (FIG. 3). Such movement of the hand lever operates through the cam **95** to shift the by-pass plunger **46** to closed position. movement within the range E—F, however, is not sufficient to change the condition of the main control valve plunger **56** which remains in closed position. Upon closure of the by-pass valve, fluid under pressure is directed through the valve assembly to the auxiliary cylinder **78** to force the piston **79** to the left as viewed in FIG. 2. When it has moved to the desired extent as determined by visual observation of the implement part or other element with which the piston is connected, further operation of the auxiliary actuator may be interrupted by returning the hand lever **85** to the neutral position.

To lower the load carried by the auxiliary actuator, the hand lever **85** is swung rearwardly or anticlockwise toward the end E of its auxiliary control range. Upon reference to FIG. 3, it will be observed that the control ranges represented by the arcs C—D and E—F overlap slightly. Accordingly, as the hand lever passes position C on its movement toward position E, and in the range between C and E, it advances position control lever **91—92** to the right sufficiently to push the valve plunger **56** to open position. This allows fluid to exhaust from the cylinder **78** as the piston **79** moves into the cylinder under the urging of its load. The lowering action may be allowed to continue under visual observation and may be terminated at will by returning the hand lever to neutral position.

MID-MOUNTED IMPLEMENTS

The hydraulic operating and control system of the present invention may be used for the operation and control of so-called mid-mounted implements as well as with implements carried by the usual trailing hitch linkage. To accommodate such implements, the tractor is conveniently provided with a depending frame **130** upon which one or more ground working tools such as cultivator shovels **131** may be mounted for movement be-

tween a raised or inactive position and a lowered or working position. Raising and lowering of the tools is effected by the power unit of the tractor through the same lift arm **25** utilized to raise and lower the hitch linkage. For this purpose, one or more crank arms **132** are nonrotatably fixed to the projecting ends of the shaft **25** and connected by links **133** with crank arms **134** nonrotatably mounted on a cross shaft **135** journalled on the tractor. Other crank arms **136** on the shaft **135** are operatively connected in known manner with means for supporting the tools **131** on the frame **130** or with supporting means for tools mounted elsewhere on the tractor as, for example, adjacent its front end.

To enable the mid-mounted tools to actuate the draft responsive means of the tractor and thus make use of the automatic draft control afforded by the system, the frame **130** is mounted for pivotal movement about a transverse, horizontal axis, in this instance on the shaft **135**. Links **137** connect the lower end of the frame to the arms **15** upon which the draft links **10** of the hitch linkage are anchored.

In the operation of the mid-mounted implements of the type above described, ground reaction on the tools **131** is transmitted as a compressive force through the links **137** to the arms **15**. The force thus applied to the arms tends to rotate the shaft **16** in the same direction in which it is rotated by tension forces produced by draft loads on the hitch links **10**. Rocking movements of the shaft **16** are transmitted to the draft control lever **89—90** which cooperates with the hand lever **85** to control the power unit for maintaining the draft load on the tools **131** substantially uniform and at a value selected by the position of the hand lever in its draft control range A—B. As the raising and lowering of the tools **130** is effected by the lift shaft **25**, the mid-mounted implement may also be operated under position control by simply swinging the hand lever **85** in its operating range C—D.

RÉSUMÉ OF OPERATION

It will be apparent from the foregoing that the invention provides a tractor hydraulic system and controls which makes it practical to operate a wide variety of implements efficiently and dependably with the tractor. The improved system provides a full range of controls for practically every implement commonly used with a tractor including automatic draft control and automatic position control. Additionally, it provides for visual control of auxiliaries associated with a tractor or with implements coupled thereto.

Selection between the various types of control as well as operation under the selected type of control is effected with ease and certainly by means of a single manually operable member such as the hand lever **85**. In the preferred form of the system illustrated, the control lever is pivoted to swing in either direction from a central, neutral position. When swung in one direction, the system is conditioned for automatic draft control and when swung in the opposite direction, it is conditioned for the automatic position control. Within each of those control ranges implement position is effectually coordinated with the position of the hand lever.

The third control range is conveniently interposed between the position and draft control ranges. Swinging of the control lever through this third range is utilized to control the operation of an auxiliary actuator or actuators.

Implements differing greatly in weight or in other characteristics may be interchangeably coupled to the tractor without requiring modification or adjustment of the controls. This is for the reason that the system automatically adapts itself for proper control of the implement through the action of a resistor valve. Implements regardless of weight are all lowered at substantially the same rate, that is, the rate found to give the best results. Response of the controls is prompt but, at the same time, violent or too rapid shifting of the control valve either manually

or automatically with the attendant excessive shock loading of the system is precluded.

Structural simplicity is enhanced by the improved arrangement for balancing the loads imposed on the hitch linkage. The balance means of the present invention has the further advantage of responding both to tension and compression loads on the hitch linkage. This materially extends the range of implement control since it provides for the actuation of implements whose overhanging weight imposes compression loads on the hitch linkage. Additionally, implements are adequately cushioned when being carried in transport position.

In general, it will be evident that the invention provides a tractor hydraulic system which is very efficient and unusually versatile. It is simple and rugged in construction. The controls for the system are simple and adapted for operation in a smooth and natural manner which greatly simplifies the work of the tractor driver.

We claim as our invention:

1. The combination in a tractor having a vertically swingable implement hitch linkage, a hydraulically operated power unit for raising and lowering the linkage and a continuously driven pump for supplying fluid under pressure to the unit, valve means controlling the delivery of pressure fluid to and exhaust of pressure fluid from the unit, other valve means operative when actuated to by-pass the pressure fluid supplied by the pump, a hand lever pivoted on the tractor adjacent said valve means to swing in opposite directions from a neutral position, means operable by said hand lever when in neutral position for actuating said other valve means, alternatively available draft load and position responsive controls for said valve means, said draft load responsive control including a member shiftable by said hand lever when swung in one direction to actuate said valve means to maintain a uniform draft load on the linkage at a value determined by the extent of displacement of the hand lever from its neutral position, and said position responsive control including a member shiftable by the hand lever when swung in the other direction to actuate said valve means for raising or lowering the linkage in positional agreement with the setting of said hand lever.

2. In a tractor, having a hitch linkage for coupling a ground working implement in trailing relation to the tractor including a pair of laterally spaced draft links, means for connecting the draft links to the tractor comprising a shaft supported on the tractor to rock about a generally transverse horizontal axis, a pair of arms rigid with and depending from opposite ends of said shaft, means pivotally connecting the ends of the draft links to the respective arms so that a draft load applied to the links tends to rock the shaft about its axis, means for yieldably resisting the rocking of the shaft including a leaf spring having one end rigidly secured to a member nonrotatably mounted on the shaft with said spring projecting radially relative to the shaft and a fixed stop mounted on the tractor at one side of said shaft and positioned for engagement by the free end of said spring.

3. In a tractor having a hitch linkage for coupling a ground working implement in trailing relation to the tractor including a pair of laterally spaced draft links, means for connecting the draft links to the tractor comprising a shaft supported on the tractor to rock about a generally transverse horizontal axis, a pair of arms rigid with and depending from opposite ends of said shaft, means pivotally connecting the ends of the draft links to the respective arms so that a draft load applied to the links tends to rock the shaft about its axis, means for yieldably resisting the rocking of the shaft comprising a lever nonrotatably fixed to said shaft and projecting radially therefrom, a leaf spring secured at one end to said lever adjacent the shaft and extending along one face of the lever, a fixed stop mounted on the tractor at one side of said shaft and engageable by the free end of the spring whereby said spring is tensioned in response to the rock-

ing of said shaft, and a cam surface formed on said one face of said lever operative to engage and progressively decrease the effective length of said spring as said shaft is rocked about its axis.

4. In a tractor, in combination, a shaft supported for rotation about a horizontal generally transverse axis, radially projecting-arms fixed to opposite ends of said shaft, implement coupling draft links pivotally connected to the respective arms, means for resisting rotation of the shaft by tension and compression forces transmitted through said draft links comprising a lever non-rotatably fixed to the shaft and projecting radially therefrom, a pair of leaf springs each rigidly attached at one end to said lever adjacent said shaft and projecting along said lever, a fixed stop on the tractor positioned for engagement by the free end of one of said springs upon application of a force tending to rock the shaft in one direction, and a second fixed stop on the tractor positioned for engagement by the free end of the other of said springs upon application of a force tending to rock the shaft in the opposite direction.

5. In a tractor, in combination, a shaft supported for rotation about a horizontal generally transverse axis, radially projecting arms fixed to opposite ends of said shaft, implement coupling draft links pivotally connected to the respective arms, means for resisting rotation of the shaft by tension and compression forces transmitted through said draft links comprising a lever secured at one end to said shaft and projecting radially therefrom, leaf springs each secured at one end to said lever adjacent said shaft and respectively extending along opposite faces of said lever, fixed stops on the tractor cooperating with the free ends of the respective springs to resist rotation of the shaft in either direction, and a cam surface formed on one face of said lever operative to progressively reduce the effective length of the adjacent spring and thus increase the resistance opposed to rotation of the shaft as it is rocked in one direction.

6. In a tractor having a hitch linkage including a draft link, a power unit operative to raise and lower the linkage, a shaft rotatably supported on the tractor, means providing a connection between said draft link and said shaft effective to rock the shaft in opposite directions in response to tension and compression forces applied through the draft link, a first spring yieldably resisting rocking of said shaft in one direction, a second spring yieldably resisting rocking of said shaft in the other direction, and means operative to progressively increase the resistance opposed to rotation of said shaft by one of said springs as the shaft is rocked in the direction opposed by that spring.

7. In a tractor having a trailing hitch linkage and a hydraulically operated power unit for raising and lowering the linkage, valve means for controlling said power unit, a hand lever fixed to one end of a shaft pivoted on the tractor adjacent said valve means, a pair of eccentrics fixed to said shaft, a first valve actuating member rotatably mounted on one of said eccentrics, and a second valve actuating member rotatably mounted on the other of said eccentrics, the axes of said eccentrics being radially spaced from the axis of said shaft and angularly spaced with respect to each other so that either member may be moved bodily into operative relation to said valve means while the other member is moved bodily to an inactive position by rocking said hand lever and said shaft.

8. In a tractor having an implement hitch linkage and a hydraulic system including an actuator for raising and lowering the linkage, a pump supplying pressure fluid to the hydraulic system, a main control valve operative to control the supply of pressure fluid to and exhaust of fluid from the actuator, draft load responsive control means for said valve, linkage position responsive control means for said valve, a hand lever pivoted on the tractor adjacent said main valve swingable to one side of a neutral position to condition one of said control means for operating said valve and to the other side of said neutral position to condition the other control means for operating said valve, a second valve closely adjacent said main valve operable to provide a low pressure by-pass for fluid supplied by said pump, and a cam movable with said hand lever and cooperating with said second valve operative upon movement of said hand lever to neutral position to open the second valve.

9. In a tractor having an implement hitch linkage and a hydraulic system including an actuator for raising and lowering the linkage, a pump supplying pressure fluid to the hydraulic system, a main control valve operative to control the supply of pressure fluid to and exhaust of fluid from the actuator, draft load responsive control means including a valve actuating member, position responsive control means including a valve actuating member, a hand lever pivoted on the tractor, means coupling said lever to said valve actuating members effective when the lever is swung to one side of a neutral position to condition one of said actuating members for operating said valve and to the other side of said neutral position to condition the other actuating member for operating said valve, a second valve supported adjacent said main valve operable to provide a low pressure by-pass for fluid supplied by said pump, and another valve actuating member coupled to said hand lever for operating said second valve upon movement of said hand lever to neutral position, and other valve means operative to prevent exhaust of fluid from said actuator when said second valve is operated.

10. In a tractor having an implement hitch linkage and a hydraulic system including an actuator for raising and lowering the linkage, a pump supplying pressure fluid to the hydraulic system, a main control valve operative to control the supply of pressure fluid to and exhaust of fluid from the actuator, draft load responsive control means including a valve actuating member, linkage position responsive control means including a valve actuating member, a hand lever pivoted on the tractor, means coupling said lever to said valve actuating members effective when the lever is swung to one side of a neutral position to condition one of said control means for operating said valve and to the other side of said neutral position to condition the other control means for operating said valve, a relief valve operable upon a predetermined pressure rise in the system for venting the pump discharge at a relatively low pressure effective to maintain the relief valve open, a by-pass valve operable when open to by-pass the pump discharge at a substantially lower pressure effective to allow said relief valve to close, and an actuating member coupled to said hand lever operative to open said by-pass valve upon movement of the hand lever to neutral position.

11. In a tractor having a hitch linkage pivotally supported on the tractor body to swing about a horizontal axis, means for raising and lowering the linkage including a rock shaft journaled on the tractor body and operatively connected with the linkage, a crank arm fixed to said shaft and disposed within the body of the tractor, a main hydraulic actuator operable through said crank arm to rock said shaft, a pin rotatably supported on the tractor body transversely of the path described by said crank arm in the rocking of said shaft, said pin having a groove at one side affording clearance for the crank arm and a solid portion at the other side operative to block the crank ark arm against movement in a linkage lowering direction, and manually operable means for rotating said pin to selectively lock or release said shaft.

12. In a power operating system for a tractor implement hitch linkage, the combination of a hydraulic actuator mounted on the tractor and connected to the linkage for raising and lowering the same, valve means carried by the tractor controlling the pressure fluid supply for said actuator, draft load responsive control means for said valve means, position responsive control means for said valve means, a hand lever pivotally supported on the tractor through a predetermined range on opposite sides of a

neutral position, and mechanism forming a part of said control means operable by said lever when swung in one direction from the neutral position for conditioning said draft load responsive control means for operating said valve means to maintain a uniform draft load on the linkage at a value determined by the position of the hand lever and for rendering said position responsive control means inactive, said mechanism being operative when the lever is swung in the other direction from the neutral position for conditioning said position responsive control means for operating said valve means to effect the raising or lowering of the linkage in positional agreement with the hand lever and for rendering said draft load responsive means inactive.

13. The combination in a tractor having an implement hitch linkage trailingly pivoted thereon and a hydraulically operated power unit for raising and lowering the hitch linkage, valve means carried by the tractor for controlling the operation of the unit, a hand lever pivoted on the tractor to swing in opposite directions from a neutral position, alternatively available draft load and position responsive controls for said valve means, said draft load responsive control having a member shifted by said hand lever when swung in one direction into a position to actuate said valve means to maintain a uniform draft load on the linkage at a value determined by the extent of displacement of the hand lever from its neutral position, and said position responsive control having a member shiftable by the hand lever when swung in the other direction into a position to actuate said valve means for raising or lowering the linkage in positional agreement with the setting of said hand lever.

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