

Jan. 15, 1963

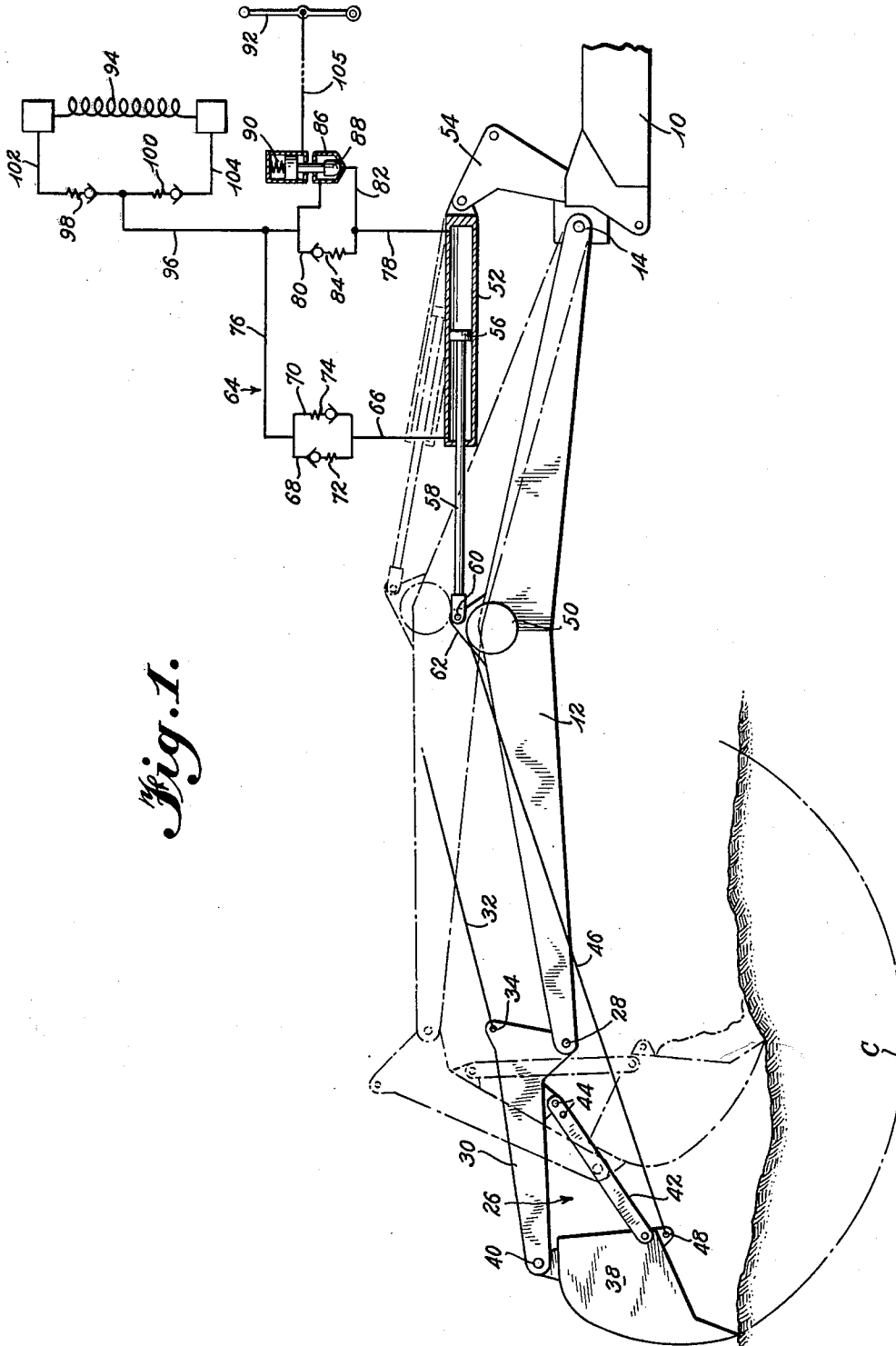
F. J. STRNAD

3,073,465

HYDRAULIC CROWD AND RETARDING CONTROL SYSTEMS FOR
TRENCH HOE ATTACHMENTS OR THE LIKE

Filed Jan. 13, 1958

4 Sheets-Sheet 1



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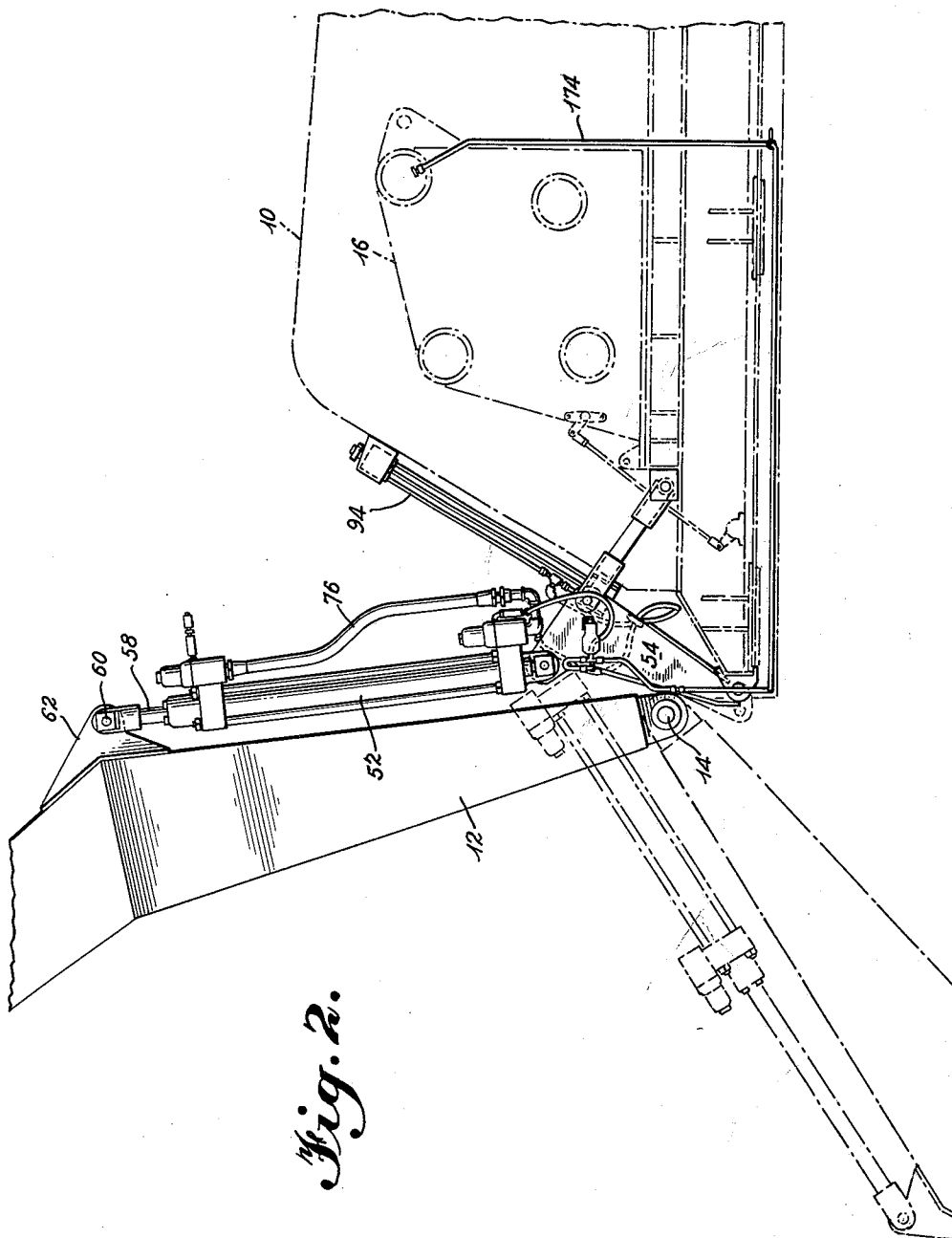
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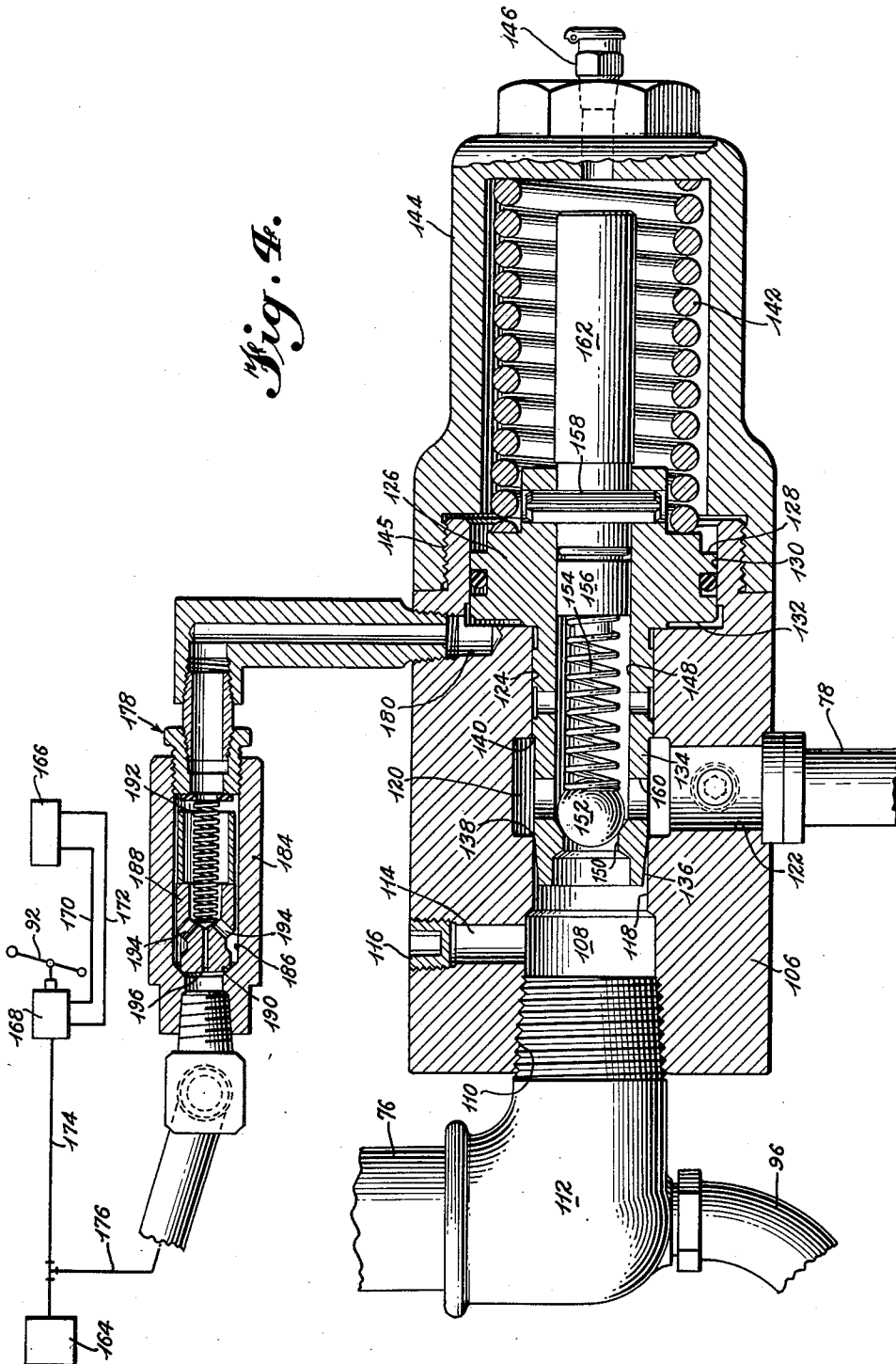
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Fig. 4.



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HYDRAULIC CROWD AND RETARDING CONTROL SYSTEMS FOR TRENCH HOE ATTACHMENTS OR THE LIKE

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14 Claims. (Cl. 214-140)

This invention relates to control systems for trench hoe attachments, or the like, and more particularly to control systems supplemental to the normal raising and lowering means for the trench hoe boom for controlling the movement of the boom to improve the efficiency of operation of the hoe attachment.

In the usual trench hoe attachment of the type with which this invention is concerned, a hoe carrying boom is pivotally supported for movement about a horizontal axis mounted upon the rotating base of the machine. The boom is raised about the axis by means of a cable which is wound around the hoist drum, and lowering movement of the boom is accomplished by the action of gravity upon the boom under the control of a brake assembly associated with the drum. The actual digging is accomplished by a bucket which is pivotally mounted on an arm that in turn is pivotally connected to the outer end of the boom.

In normal operation, the boom is lowered to place the bucket in digging position with the arm extending generally outwardly from the outer end of the boom and the digging teeth of the bucket pointing vertically downwardly in contact with the ground with the open side of the bucket facing inwardly toward the boom. An inhaul cable, attached to the bucket, is then operated to pivot the bucket and its attached arm downwardly and inwardly of the boom to scoop earth into the bucket.

Due to the fact that the only downward forces exerted upon the bucket are the gravitational forces acting upon the bucket and boom, a problem has arisen in situations where the upward reaction of the earth on the bucket assembly is greater than the downwardly acting gravitational force on the boom. In one of these types of operations, the trench being dug is of substantial depth and as a result, when the bucket is lowered to its digging position, the boom is disposed considerably below the horizontal, or nearly vertical. In this situation, the geometry of the boom suspension is such that the weight of the boom and bucket is not fully effective in exerting a downward force on the bucket during the digging operation, and thus resulting in raising of the bucket arm pivot point at the tip of the boom with the result that the bucket is raised and a shallow cut is produced. A similar result occurs in the other type of situation where the hardness of the earth being dug is such as to exert a substantial resistance to downward movement of the bucket.

While the foregoing conditions could be eliminated by increasing the weight of the bucket, arm and boom, such a solution would be impractical due to the additional load on the hoist brake and hoist cable drum drive.

It is a primary object of the invention to provide a control system which may be employed with existing or new trench hoe attachments to increase the digging efficiency of such attachments.

It is another object of the invention to provide a control system adapted for use on trench hoe attachments which supplements the conventional hoisting and lowering mechanism in controlling movements of the hoe boom assembly.

Still another object of the invention is to provide a control system adapted for use on trench hoe attachments

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which is operable to resist undesired movements of the boom and bucket during digging operations but does not interfere with their normal movements.

Still another object of the invention is to provide a control system adapted for use on trench hoe attachments which controls the lowering movement of the boom assembly in such a manner as to minimize undesirable shock loading of the attachment when it is carelessly used as a pick in hard material.

Still another object of the invention is to provide a control system adapted for use on trench hoe attachments which is completely automatic in operation and requires no additional attention or control by the operator.

Other objects and advantages of the invention will become apparent by reference to the following specification taken in conjunction with the accompanying drawings.

In the drawings:

FIG. 1 is a side elevational view of certain parts of a trench hoe attachment and includes a schematic showing of one form of control system embodying the invention;

FIG. 2 is a partial detail side elevational view of a trench hoe attachment showing portions of the control system of FIG. 1;

FIG. 3 is a partial plan view of the structure shown in FIG. 2, with certain parts omitted for the sake of clarity, and other parts added, and

FIG. 4 is a longitudinal cross sectional view of a valve assembly especially adapted for use in the control system of FIG. 1.

Referring first to FIGS. 2 and 3 of the drawings, a trench hoe assembly embodying the present invention is shown mounted upon the rotating base of a crawler unit 10 of more or less conventional design which is partially illustrated in broken lines. At the forward end of the unit 10, a trench hoe boom 12 is pivotally supported for movement about a horizontal axis by a trunnion assembly 14 mounted on the base of the unit 10. An upper frame 16 is mounted within the cab of the unit 10 and includes, among other components not shown in detail, a hoist cable drum 18 and an inhaul cable drum 20, both of which are provided with clutch assemblies 22 and 24, respectively, which are operable to drive the respective drums from a conventional power plant, not shown, mounted within the cab of the unit 10.

Referring now to FIG. 1, a bucket assembly 26 is supported at the tip of the boom 12 for pivotal movement about an axis defined by the pivot pin 28. The bucket assembly 26 includes a bucket arm 30 which functions as a bell crank element pivoted upon the pin 28 and controlled in its movements by means of a hoist cable 32 coupled to the arm at 34 and extended in any desired manner, not shown, to the hoist drum 18. It is believed apparent that actuation of the drum 18 to wind the cable 32 upon the drum will cause the boom 12 and the bucket assembly 26 to be elevated about the axis defined by the trunnion assembly 14. Lowering movement of the boom and bucket assembly under gravitational forces is controlled by permitting the cable 32 to unwind from the hoist drum 18 while controlling rotation of the drum by means of a schematically illustrated brake assembly 36.

At the outer end of the arm 30, a bucket 38 is supported by a pin 40. A bracing link 42 is pinned at one end to the bucket 38 and at its outer end to the arm 30. By adjusting the effective length of the link 42, as by providing a series of holes 44, the orientation of the bucket 38 with respect to the arm 30 may be varied at will. To move the bucket assembly 26 in a digging operation, an inhaul cable 46 is connected to the bucket 38, as at 48, and conducted over a series of pulleys, such as 50, to the inhaul drum 20. By winding the cable 46 onto the

drum 20, the bucket assembly 26 may be moved in a counterclockwise direction about the pivot pin 28 to assume a position substantially beneath the tip of the boom 12. During this movement, the bucket 38 will scoop up a load of earth from the working location.

The structure described above is quite typical of trench hoe attachments presently in use. The substantial mass of the boom and bucket assembly eliminates any need for providing power driven means for lowering the assembly about the axis at 14. As previously indicated, the lack of a positive driving force applied to the boom and bucket assembly to move or maintain the assembly in a selected position creates certain problems, one of which is apparent from a comparison of the respective positions of the boom and bucket assemblies illustrated in full lines and in broken lines in FIG. 1.

In FIG. 1, the full line illustration of the assembly shows the various parts in their position immediately prior to a scooping or digging operation. To perform such an operation, the inhaul drum 20 is actuated to wind in the cable 46, thus pivoting the bucket assembly 26 about the pivot pin 28. If the mass of the boom and the bucket assembly is not sufficient to force the bucket 38 downwardly into the earth so that the tip of the bucket follows the curved path C, the reaction between the bucket 38 and the earth surface forces the boom 12 to move upwardly in a clockwise direction about the pivot 14 and, at the end of the scooping operation, the parts assume a position similar to that illustrated in broken lines in FIG. 1. Obviously, this shallow cut does not fully load the bucket, thus decreasing the efficiency of operation of the trench hoe.

The situation discussed above occurs where the earth being dug is extremely hard. It also occurs quite frequently when the digging operation is performed at depths substantially below the elevation of the pivot 14, since downward movement of the boom 12 about the pivot 14 shortens the effective lever arm of the weight of the boom and the bucket assembly, thus decreasing the downward force exerted on the earth by the bucket 38.

In an effort to overcome difficulties of the foregoing nature, the operator frequently attempts to use the bucket 38 as a pick by elevating the boom and the bucket assembly to a substantial height and permitting it to drop freely without applying the brake 36 to control such downward movement. While this action may in part overcome the before-mentioned difficulties, the shock loading applied to the boom and bucket assemblies at the moment of impact materially shortens the active life of these units and hence is considered an undesirable practice.

To eliminate the foregoing difficulties, a supplemental control system, shown schematically in FIG. 1, is used in conjunction with the trench hoe attachment described above. The system includes a closed hydraulic cylinder 52 which is pivotally supported at one end upon a lug 54 rigidly affixed to the base of the unit 10. The cylinder 52 is filled with a hydraulic fluid and a piston 56 is mounted within the cylinder for movement between the ends of the latter. A piston rod 58 is fixed to the piston and extends from one end of the cylinder 52 through a suitable opening having sealing means, not shown, which permits movement of the rod 58 through the end wall of the cylinder without the loss of any hydraulic fluid through the opening. The opposite end of the rod 58 is pivotally coupled at 60 to a lug 62 fixedly mounted upon the upper surface of the boom 12. Pivotal movement of the boom 12 about its pivot 14 causes the piston 56 to be reciprocated within the cylinder 52.

A closed hydraulic circuit 64 is connected to permit the fluid to flow from one end of the cylinder 52 to the other upon movement of the piston 56. The hydraulic circuit 64 includes a first conduit 66 which is connected to the cylinder 52 to permit fluid to flow from the rod end of the cylinder upon movement of the piston 55

toward the latter end. The conduit 66 also returns fluid to the rod end of the cylinder upon movement of the piston 56 in the opposite direction. The conduit 66 is split into a pair of parallel branch lines 68 and 70, each of which is provided with a one-way check valve 72 and 74, respectively, which are oppositely oriented to control the flow of fluid in opposite directions. The flow of fluid from the rod end of the cylinder occurs through the check valve 74 after a pressure sufficient to unseat the valve has been developed within the rod end of the cylinder and conduit 66.

Fluid flowing through the check valve 74 and the branch conduit 70 is conducted by a conduit 76 to a conduit 78 which is connected to the opposite or piston end of cylinder 52. In the schematic representation of FIG. 1, conduit 78 is also split into a pair of parallel branch lines 80 and 82, respectively, each of which is provided with a one-way check valve for controlling the flow of fluid through the respective branch line. The conduit 80 is provided with a conventional one-way check valve oriented to permit the fluid to flow from the conduit 76 to the conduit 78 and hence into the piston end of the cylinder 52. The conduit 82 is provided with a type of pilot operated resistance valve 86 which may be opened to permit fluid to flow from the piston end of the cylinder—i.e., from the conduit 78 to the conduit 76 when either of two conditions obtain.

One of these conditions is the existence of a selected pressure in the piston end of the cylinder 52 and the conduit 78 sufficient to unseat the valve head 88 against the biasing action of a spring 90. The valve head 88 may also be provided with suitable means whereby the manual operation of the hoist drum control lever 92 can bring about movement of the valve head 88 away from its seat to permit the flow of fluid from the conduit 78 to the conduit 76 irrespective of the magnitude of the pressure within the conduit 78. No specific structural arrangement is illustrated in FIG. 1 for accomplishing this last-mentioned opening of the valve 86, however, it is believed apparent that a suitable hydraulic, pneumatic, electrical or mechanical coupling between the hoist drum lever 92 and the valve head 88 may be employed to accomplish this purpose. One specific structural arrangement for accomplishing this hydraulically is illustrated in FIG. 4 and will be described in greater detail below.

The function of the valve 86 is to provide a substantial amount of resistance to the flow of fluid from the piston end of the cylinder 52 through the conduits 78 and 76. To accomplish this purpose, the biasing spring 90 is made extremely stiff in order to require a substantial pressure in the conduit 78 before the valve head 88 is moved away from its seat. From an inspection of FIG. 1, it is believed apparent that an upward movement of boom 12 about its pivot 14—that is, in a clockwise direction in FIG. 1—will cause the piston 56 to move toward the right, or piston end, of the cylinder 52, thus exerting a pressure on the fluid between the piston 56 and the piston end of the cylinder. By preventing the flow of fluid from the piston end of the cylinder, a substantial resistance to the movement of the boom 12 in a clockwise direction is developed. This resistance is employed to prevent movement of the boom 12 from the full line position of FIG. 1 toward the broken line position during a scooping operation of the bucket 38. Hence, the resisting action of the valve 86 assists the mass of the boom and bucket assembly in forcing the bucket downwardly to penetrate the earth during the scooping operation.

In view of the substantial pressures developed by the fluid passing through the valve 86 during the last-mentioned operation, and through the valve 74 during lowering of the boom, the fluid frequently becomes overheated. To cool fluid heated in this manner, a heat exchange unit in the form of a radiator 94 is connected into the conduit 76 by a conduit 96. A pair of oppositely disposed

the conduits 76 and 96 may be connected to the passage 108. A bleed port 114 is bored through the body 106 to intersect the passage 108 in the enlarged diameter portion, the bleed port 114 being normally sealed by a screw plug 116. At the inner end of the enlarged diameter portion, a reduced diameter portion 118 is formed in the passage 108 to connect the enlarged diameter portion to an internal valve chamber 120. A transverse port 122 is bored into the valve body 106 to communicate with the chamber 120. The port 122 is provided with suitable coupling means to connect the conduit 78 thereto. The portion 124 of the passage 108 to the right of the chamber 120 is bored to a diameter slightly larger than the reduced diameter section 118 but smaller than the diameter of the chamber 120. This section 124 serves to guide the rod of a piston assembly designated generally 126 which includes a piston 128 reciprocable in an enlarged diameter section 130 at the extreme right-hand portion of the passage 108. At its left hand or inner face, the piston 128 is relieved slightly as at 132 to provide a chamber for receiving fluid to operate the piston.

Referring now to the piston assembly 126, an elongated extension 134 is tapered at 136 to a diameter which sealingly engages the innermost end 138 of the reduced diameter section 118. The sealing engagement between the left-hand end of extension 134 and the right-hand edge 138 of the reduced diameter section 118 performs the function of the valve 86 in FIG. 1.

The extension 134 is provided with a slightly enlarged diameter section beginning at a face 140. The face 140 functions as a valve operating piston to move the entire piston assembly 126 to the right when the pressure within the chamber 120 reaches a preselected value. The portion of the extension 134 to the right of the face 140 is slidably received within the enlarged diameter section 124 of the passage 108.

Movement of the piston assembly 126 to the right upon the application of pressure to the chamber 120 is resisted by a stiff helical spring 142 which corresponds functionally to the spring 90 schematically illustrated in FIG. 1. The spring 142 is seated upon the piston 128 and is held against the piston by a cap 144 which is threadedly engaged with the valve body 106, as at 145. A spring chamber breather 146 connects the interior of the cap 144 to the atmosphere to permit equalization of the pressure in the spring chamber.

The extension 134 of the piston assembly 126 is provided with a longitudinally extending bore 148 having a reduced diameter portion 150 which defines a seat for the ball 152 of a one-way check valve assembly mounted in the interior of extension 134. The ball 152 is biased against its seat by means of a compression spring 154 seated upon one end of a shaft 156 fixedly secured to the piston assembly 126 as by a coupling pin 158. A transversely extending passage 160 in extension 134 connects the passage 148 to the chamber 120 in the valve body 106. The one-way check valve formed by the elements 150, 152 and 154 corresponds functionally to the one-way check valve 84 of FIG. 1.

The shaft 156 is provided with an integral extension 162 located within the coils of the spring 142. By removing the spring breather fitting, and suitably drilling and tapping the extension 162, the piston assembly 126 may be coupled to a suitable mechanical linkage operable to move the piston assembly to the right against the biasing action of spring 142. Such a linkage will be coupled to the hoist drum clutch operating means in such a manner that when the clutch lever 92 is actuated to effect winding in of the cable 32 to elevate the boom, the piston assembly 126 will be moved to the right to open communication between the conduit 78 and the T-coupling 112 to permit fluid to flow from the conduit 78 to the conduit 76. Since suitable linkages may vary widely in accordance with the particular hoist drum control system employed and may be completely mechanical or electro-

mechanical, no specific structure of this type has been illustrated.

Rather than illustrating a specific mechanical arrangement, a suitable coupling has been disclosed whereby the piston assembly 126 may be moved to the right upon actuation of the hoist drum control lever 92 of a hydraulically operated hoist drum control clutch schematically illustrated at 164, which corresponds to the clutch assembly 22 illustrated in FIG. 3.

A typical hydraulic clutch operating system is schematically illustrated in FIG. 4 and conventionally includes a pump 166 which may be driven from the same prime mover assembly employed to drive the various cable drums. The pump 166 is connected to a valve 168 by a high pressure line 170 and a low pressure or return line 172. The valve 168 is actuated by the hoist drum control lever 92 to selectively connect either of the lines 170 or 172 to a conduit 174 which connects the outlet port of the valve 168 to the hydraulic operator of the hoist drum clutch illustrated at 164. To actuate the clutch operator 164 to connect the drum 18 to the prime mover, the lever 92 is moved into a position wherein the high pressure line 170 is connected through the valve 168 to the line 174 to supply pressure to engage the clutch. Engagement of the clutch causes the hoist drum 18 to be driven by the prime mover to wind in the cable 32, thereby swinging the boom assembly 12 upwardly about its pivot 14.

Since the free flow of fluid from the piston end of the cylinder 52 through the conduit 78 to the conduit 76 is desirable at this time, the high pressure supplied to the conduit 174 is also applied to a conduit 176 which is connected through a valve fitting generally designated 178 to a bore 180 in the valve body 106. Fluid under pressure passing through the bore 180 is applied to the left hand face 132 of the piston assembly 126.

The fitting 178 includes a body 184 having a longitudinal bore 186 extending therethrough within which is mounted a spring pressed valve member 188 normally urged into sealing engagement with a reduced diameter portion 190 of the bore 186 by means of a compression spring 192. The valve member 188 is bored as at 194 to provide relatively unrestricted flow of fluid through the body 184 when the valve 188 is moved to the right away from its seat 190. When the valve is seated, flow through the valve is substantially restricted by requiring the flow to take place through a restricted orifice 196, thus cushioning return movement of the piston assembly 126 to its FIG. 4 position.

When the valve of FIG. 4 is employed in a control system of the type shown in FIG. 1, it is connected into the FIG. 1 circuit as indicated in FIG. 4, with the T-fitting 112 performing the functions of connecting the conduit 76 to the conduit 96 and to the valve body 106. Conduit 78 of FIG. 1 is connected to the port 122 in the manner indicated in FIG. 4. The fitting 178 and the associated conduits 176, 174, valve 168, etc., correspond functionally to the schematically illustrated coupling 105 of FIG. 1.

Upon lowering of the boom assembly, fluid expelled from the rod end of the cylinder 52 passes through conduit 76 and, now referring to FIG. 4, passes through the T-fitting 112 into the left hand end of passage 108. Since the fluid entering passage 108 is under pressure, it unseats the ball 152 from its seat and flows through the passage 160 into chamber 120 and hence through the port 122 into the conduit 78 to the piston end of the cylinder 52. The spring 154 employed to bias the ball 152 against its seat is relatively light and hence the piston assembly 126 remains in the FIG. 4 position, all flow occurring through the ball check valve 152. As in the operation previously described above, the fluid expelled from the rod end of the cylinder 52 is insufficient to fully fill the void remaining in the piston end of the cylinder, due to the volume of the rod 58, and hence the additional fluid for filling this void is withdrawn from the radiator 94

one-way check valves 98 and 100, respectively, are connected in conduits 102 and 104 to control the direction of flow of fluid through the radiator 94.

At the starting point of the digging operation, it will be assumed that the boom assembly 12 is at some elevated position and is to be lowered to the position shown in FIG. 1 prior to the performance of the digging operation. To lower the boom assembly 12 from its elevated position, the operator actuates the hoist drum control lever 92 to disengage the hoist drum clutch to permit the boom to move toward the FIG. 1 position under the influence of gravity. Conventionally, the downward movement of the boom is controlled by operation of the brakes 36 by conventional means, not shown. However, momentarily neglecting the operation of the brakes, it will be apparent that as the boom assembly 12 moves downward—that is, in a counterclockwise direction about pivot 14 in FIG. 1—the piston 56 will be drawn by the lowering boom toward the rod or left-hand end of the cylinder 52. Movement of the piston 56 to the left in FIG. 1 induces a flow of fluid from the rod end of the cylinder into the conduit 66. Flow of fluid from the conduit 66 through the branch line 68 is prohibited since flow in this direction biases the valve 72 more firmly upon its seat. Thus, flow from the conduit 66 can occur only through the one-way check valve 74 in the branch line 70. The valve 74 may be adjusted to exert a selected resistance to the flow of fluid through the valve by suitable selection of the characteristics of the conventional valve spring. In this particular instance, a spring of substantial strength is selected to prevent the flow of fluid from the conduit 66 to the conduit 76 until the pressure in the rod end of the cylinder 52 and the conduit 66 has built up to a value of the order of 3,000 lbs. per square inch.

When this pressure is achieved, the valve 74 opens and fluid passes from the conduit 66 to the conduit 76. Since the fluid expelled from the rod end of the cylinder 52 must fill the void left in the piston end of the cylinder by the leftward movement of the piston 56, all of the fluid expelled from the rod end of the cylinder 52 passes from the conduit 76 into the conduit 80 and thence past the ball check valve 84 into the conduit 78 and thence to the piston end of the cylinder 52. The biasing force of the spring associated with the valve 84 is very slight, in fact the purpose of this valve is not to resist flow, but merely to prevent flow through the conduit 80 in the direction from the conduit 78 to the conduit 76.

Because of the volume occupied by the portion of the rod 58 in the rod end of the cylinder 52, the amount of fluid expelled from the rod end of the cylinder 52 by a leftward movement of the piston 56 is insufficient to completely fill the piston end of the cylinder 52. The necessary additional amount of fluid to maintain the piston end of the cylinder 52 completely filled is obtained from the heat exchange unit radiator 94. Due to the orientation of the check valves 98 and 100 associated with the radiator, the fluid extracted from the radiator 94 comes from the lowermost end of the radiator and hence has passed fully through the cooling cycle within the radiator prior to its withdrawal and return to the cylinder 52.

With the boom 12 positioned in its digging position, the inhaul drum 20 is actuated by engaging its clutch 24 by a suitable control mechanism, not shown, to wind in the cable 46, thus pivoting the bucket and arm assembly in a counterclockwise direction about the pivot 28. Upward forces exerted on the end of the boom 12, due to the reaction between the bucket 38 and the earth, act upon the boom 12 in a manner tending to pivot it in a clockwise direction about the pivot 14. Because of the presence of the cylinder 52 and its piston, clockwise movement of the boom 12 about the pivot 14 can occur only by forcing piston 56 to move to the right through cylinder 52. Thus, the upward forces exerted on the outer

end of the boom, due to the reaction between the bucket 38 and the earth, develop a pressure in the piston end of the cylinder 52 and conduit 78.

This pressure is applied to the valve 86 and attempts to open the valve against the biasing action of the spring 90. The spring 90 is chosen to prevent flow of fluid through the conduit 82 until the pressure within the conduit reaches 3,000 pounds per square inch. When this pressure is reached, the valve 86 opens and fluid flows from the piston end of the cylinder 52 through the conduit 78, conduit 82, conduit 76 and through the valve 72 into the rod end of the cylinder via the conduit 66. As soon as this communication is established, the valve 86 bleeds off the pressure in conduit 82 which is in excess of the value determined by the spring 90. In this manner, a substantial resistance to upward movement of the boom 12 about its pivot 14 is exerted, thus forcing the teeth of the bucket 38 to penetrate the earth and scoop the earth from the trench in an efficient manner.

When the scooping operation is completed, the operator then elevates the boom 12 in order to remove the earth from the trench. To elevate the boom, the hoist control lever 92 is actuated to engage the hoist drum clutch 22, thereby coupling the hoist drum to the prime mover to rotate the drum 18 and wind in the cable 32 to elevate boom 12. In order to avoid the substantial load which would otherwise be placed on the hoisting mechanism by the resisting action of the valve 86, the hoist control lever 92 is coupled to the valve 86 in a manner such that movement of the lever 92 to the boom hoisting position opens the valve 86 to permit free flow of fluid from the piston end of the cylinder 52. Suitable couplings between the lever 92 and valve 86 may take many forms which are dependent primarily upon the specific structure of the valve 86 and the lever 92 as well as their relative locations. Hence, the coupling mechanism which acts to open the valve 86 when the boom hoisting mechanism is actuated is illustrated schematically at 105 in FIG. 1 and it is to be understood that reference numeral 105 indicates any electrical, mechanical or hydraulic means capable of performing the foregoing function. One specific form of hydraulic means which may be employed is shown in FIG. 4 and will be described in greater detail below.

Since the volume of fluid expelled from the piston end of the cylinder 52 by hoisting movement of the boom 12 is greater than the volume required to fill the rod end of the cylinder 52, due to the volume occupied by the piston rod 58, the excess fluid expelled from the piston end of the cylinder 52 passes through the conduit 96 and the one-way valve 98 into the radiator 94 of the heat exchange unit. Since this fluid has been heated during the previous lowering movement of the boom assembly 12, it is passed through the radiator to be cooled and returned to the cylinder during the next subsequent lowering movement of the boom. Thus, the heat exchange unit serves not only to cool fluid heated by its high pressure passage through the resistance valves 74 and 86 (using the FIG. 1 identification), but also serves as a reservoir for handling the differential volume of fluid required by the volumetric differences occasioned by the portion of the piston rod 58 located within the rod end of the cylinder 52.

Referring now to FIG. 4, one form of construction for performing the function of the valve 86 is illustrated in some detail. The specific construction shown in FIG. 4 also incorporates a valve for performing the function of the one-way check valve 84, hence the structure shown in FIG. 4 may be considered to incorporate both the conduits 80 and 82 as well as the valves 84 and 86.

The valve of FIG. 4 includes a main valve body 106 having a longitudinal passageway 108 extending entirely through the valve body 106. At the left-hand end of the valve body, the passage 108 is enlarged and threaded as at 110 to receive a T-coupling 112 by means of which

through the conduit 96 and passes through the T-fitting 112 and the ball valve 152 into the conduit 78.

Since the hoist control lever 92 is actuated to its lowering position at this time, the low pressure conduit 170 from the pump 166 is connected through the valve 163 to the conduits 174 and 176, hence no pressure is applied through the fitting 178 to act against the piston 128.

During the scooping operation, the pressure exerted against the fluid in the piston end of the cylinder 152 is transmitted through the conduit 78 and into the chamber 120. The pressure within the chamber 120 acts against the piston face 140 and attempts to move the piston assembly 126 to the right in FIG. 4. This movement is resisted by the spring 142. When the pressure within the chamber 120 becomes sufficient to move the piston assembly 126 to the right against the biasing action of the spring 142, the tapered portion 136 of extension 134 is moved to the right to open communication between the chamber 120 and the left hand edge end of passage 108 to permit a controlled amount of fluid to flow from the piston end of the cylinder 52. The resistance to the flow of fluid from the piston end of the cylinder 52 in the foregoing manner applies a substantial amount of resistance to upward movement of the boom as discussed in connection with the valve 86 in the schematic FIG. 1 control system.

When it is desired to hoist the boom assembly, the operator actuates the hoist control lever 92 to its hoist position and thereby connects the high pressure conduit 172 to the conduit 174 through the valve 163. The high pressure fluid flows through the conduit 174 to actuate the hoist drum clutch to reel in the cable 32. Fluid under pressure also passes from the conduit 174 through the conduit 176 and the fitting 178 into the chamber defined by the relieved left hand face 132 of the piston 128. Since the area of the face 132 is quite substantial, the hoist drum clutch operating pressure is sufficient to move the piston assembly 126 to the right against the action of the spring 142 to open communication between the chamber 120 and the fitting 112 to permit free flow of fluid from the conduit 78 to the conduit 76.

While I have described in detail a single embodiment of my invention, it will be apparent to those skilled in the art that the specific embodiment is capable of modification. Therefore, the foregoing specification is to be considered exemplary rather than limiting, and the true scope of my invention is that defined in the following claims.

Having thus described the invention, I claim:

1. A control system for a trench hoe or the like having a boom mounted for movement about a horizontal pivot, means for hoisting and lowering said boom about said pivot, and means for controlling the operation of said boom hoisting and lowering means; said system comprising a closed hydraulic circuit, means connected in said circuit and coupled to said boom to induce a flow of fluid in said circuit in a first direction upon hoisting movement of said boom about said pivot, valve means connected in said circuit to prevent fluid from flowing through said circuit in said first direction prior to the development of a preselected minimum pressure in said circuit, said valve means yielding to permit fluid to flow through said circuit in said first direction if pressure is developed in said circuit which exceeds said preselected minimum, and means coupling said valve means to said hoisting and lowering operation controlling means to condition said valve means to permit fluid to flow through said circuit in said first direction at pressures below said preselected minimum pressure when said hoisting and lowering means is actuated to hoist said boom.

2. A control system for a trench hoe or the like including a boom mounted for movement about a horizontal pivot, and means for hoisting and lowering said boom about said pivot; said system comprising a closed hydraulic circuit, means connected in said circuit and cou-

pled to said boom to induce a flow of fluid in said circuit in one direction upon hoisting movement of said boom and to induce a flow of fluid in said circuit in the opposite direction upon lowering movement of said boom, first valve means connected in said circuit to permit fluid to flow through said circuit in said one direction only when a first selected minimum pressure is exceeded, second valve means connected in said circuit to bypass said first valve means and permit the flow of fluid through said circuit in said opposite direction only when a second selected minimum pressure is exceeded, and means coupling said hoisting and lowering means to said first valve means to condition said first valve means to permit the free flow of fluid through said circuit in said one direction at pressures below said first selected minimum pressure when said hoisting and lowering means is actuated to hoist said boom assembly.

3. For use in combination with a trench hoe attachment or the like having a boom assembly mounted for movement about a horizontal pivot upon a base, and hoist means on said base for hoisting and lowering said boom assembly about said pivot; means for selectively resisting upward movement of said boom assembly about said pivot comprising a closed cylinder filled with fluid and having a piston mounted for axial movement therein, means coupling said cylinder and said piston between said boom assembly and said base to move said piston toward one end of said cylinder when said boom assembly is moved upwardly about said pivot, conduit means connected to said cylinder to permit fluid to flow from said one end of said cylinder upon upward movement of said boom about said pivot, valve means connected in said conduit means to control the flow of fluid therethrough, said valve means including a valve seat and a valve head movable into and out of sealing engagement with said valve seat, means biasing said valve head into sealing engagement with said valve seat, means on said valve head operable to move said valve head away from said seat when a predetermined pressure is achieved in said one end of said cylinder, and means coupled to said hoist means for moving said valve head out of sealing engagement with said valve seat against the action of said biasing means when said hoist means is actuated to hoist said boom assembly.

4. For use in combination with a trench hoe attachment or the like having a boom assembly mounted for movement about a horizontal pivot upon a base assembly, and means on said base for hoisting and lowering said boom assembly about said pivot; supplemental means for controlling movement of said boom assembly about said pivot comprising a closed cylinder filled with fluid and having a piston mounted for axial movement therein, means coupling said cylinder to one of said assemblies, means coupling said piston to the other of said assemblies whereby movement of said boom assembly about said pivot causes axial movement of said piston relative to said cylinder, a closed hydraulic circuit connecting opposite ends of said cylinder to permit fluid to flow from one end of said cylinder to the other upon movement of said piston within said cylinder, first valve means connected in said hydraulic circuit and continuously active to regulate the flow of fluid in said circuit generated by a lowering movement of said boom assembly to exert a predetermined resistance to said lowering movement, and second valve means connected in said circuit in parallel relation to said first valve means and being manually operative for selectively applying and withdrawing resistance to the flow of fluid in said circuit which is generated by a hoisting movement of said boom assembly.

5. Boom assembly control means as recited in claim 4 wherein said second valve means includes resistance means normally disposed to exert a predetermined resistance means normally disposed to exert a predetermined resistance to the flow of fluid generated by hoisting movement of said boom assembly to thereby resist

said hoisting movement, and means coupled to said hoisting and lowering means to render said resistance means ineffective to resist the last mentioned flow of fluid when said hoisting and lowering means is actuated to hoist said boom assembly.

6. Boom assembly control means as defined in claim 4 wherein said second valve means includes a valve having a valve seat, a valve head sealingly engageable with said seat, means normally biasing said valve head toward said seat to resist the flow of fluid in said circuit generated by hoisting movement of said boom assembly, and means coupled to said hoisting and lowering means for overcoming said biasing means to move said valve head away from said valve seat upon actuation of said hoisting and lowering means to hoist said boom assembly.

7. For use in combination with a trench hoe attachment or the like having a boom assembly mounted for movement about a horizontal pivot upon a base assembly, and means on said base assembly for hoisting and lowering said boom assembly about said pivot; supplemental means for controlling movement of said boom assembly about said pivot comprising a closed cylinder filled with fluid and having a piston mounted for axial movement therein, means coupling said cylinder to one of said assemblies, means coupling said piston to the other of said assemblies whereby pivotal movement of said boom assembly about said pivot causes axial movement of said piston relative to said cylinder, a closed hydraulic circuit connecting opposite ends of said cylinder to permit fluid to flow from one end of said cylinder to the other upon movement of said piston within said cylinder, first flow control means connected in said hydraulic circuit to regulate the flow of fluid in said circuit generated by a lowering movement of said boom assembly to exert a predetermined resistance to said lowering movement, second flow control means connected in said circuit for controlling the flow of fluid in said circuit generated by a hoisting movement of said boom assembly, said second flow control means including resistance means normally disposed to exert a predetermined resistance to the flow of fluid in said circuit generated by a hoisting movement of said boom assembly, and means coupled to said hoisting and lowering means to render said resistance means ineffective to resist the last mentioned flow of fluid when said hoisting and lowering means is actuated to hoist said boom assembly.

8. For use in combination with a trench hoe attachment or the like having a boom assembly mounted for movement about a horizontal pivot upon a base assembly, and means on said base assembly for hoisting and lowering said boom assembly about said pivot; supplemental means for controlling movement of said boom assembly about said pivot comprising a closed cylinder filled with fluid and having a piston mounted for axial movement therein, means coupling said cylinder to one of said assemblies, a piston rod secured to said piston and projecting through one end of said cylinder to couple said piston to the other of said assemblies whereby movement of said boom assembly about said pivot causes axial movement of said piston relative to said cylinder, a closed hydraulic circuit connecting opposite ends of said cylinder to permit fluid to flow from one end of said cylinder to the other upon movement of said piston within said cylinder, first resistance means for regulating the flow of fluid in said circuit generated by a lowering movement of said boom assembly to exert a predetermined resistance to said lowering movement, second resistance means in said circuit for selectively resisting the flow of fluid in said circuit generated by a hoisting movement of said boom assembly, and heat exchange means connected in said circuit for cooling fluid heated by its passage through said resistance means.

9. For use in combination with a trench hoe attachment or the like having a boom assembly mounted for movement about a horizontal pivot upon a base assembly,

and means on said base assembly for hoisting and lowering said boom assembly about said pivot; supplemental means for controlling movement of said boom assembly about said pivot comprising a closed cylinder filled with fluid and having a piston mounted for axial movement therein, means coupling said cylinder to one of said assemblies, a piston rod secured to said piston and projecting through one end of said cylinder to couple said piston to the other of said assemblies whereby movement of said boom assembly about said pivot causes axial movement of said piston relative to said cylinder, a closed hydraulic circuit connecting opposite ends of said cylinder to permit fluid to flow from one end of said cylinder to the other upon movement of said piston within said cylinder, first resistance means for regulating the flow of fluid in said circuit generated by a lowering movement of said boom assembly to exert a predetermined resistance to said lowering movement, second resistance means in said circuit for selectively resisting the flow of fluid in said circuit generated by a hoisting movement of said boom assembly, and means connected in said circuit for receiving and returning to said cylinder the volumetric differences of fluid occupying the respective ends of said cylinder by movement of portions of said piston rod into and out of said cylinder.

10. Supplemental control means as recited in claim 9 wherein said receiving and returning means includes a heat exchange unit for cooling the fluid.

11. For use in combination with a trench hoe attachment or the like having a boom mounted for movement about a horizontal pivot on a base, and means for hoisting and lowering said boom assembly about said pivot; a closed hydraulic circuit, means coupled between said boom and said frame for generating a flow of fluid in said circuit in a direction dependent upon the direction of movement of said boom about said pivot, and valve means for controlling the flow of fluid in said circuit comprising a valve body having a chamber therein, first and second port means in said valve body connecting said chamber in said circuit, said second port means being in communication with said chamber at all times, a piston assembly mounted for movement in said body, valve means on said piston assembly engageable in one position with said body to stop flow of fluid from said chamber to said first port, means biasing said piston assembly to said one position, first means for moving said piston assembly away from said one position when the pressure of fluid at said second port means reaches a predetermined value, second means for moving said piston assembly away from said one position when said hoisting and lowering means is actuated to hoist said boom assembly, and means on said piston assembly for permitting fluid to flow from said first port means into said chamber when said piston assembly is located in said first position.

12. For use in the combination recited in claim 11 wherein said boom hoisting and lowering means includes a hydraulically operated clutch, and means for supplying fluid under pressure to said clutch to condition said hoisting and lowering means to hoist said boom; the improvement wherein said second means for moving said piston assembly comprises a piston face on said piston assembly, and means connecting said supplying means to supply fluid under pressure to said piston face to move said piston assembly away from said one position when fluid under pressure is supplied to said clutch.

13. A hydraulic crowd system for a trench hoe or the like having a boom mounted for movement about a horizontal pivot, means for hoisting and lowering said boom about said pivot which includes operator manipulative means for controlling the operation of hoisting and lowering said boom; said hydraulic crowd system comprising a closed hydraulic circuit, means connected in said circuit and coupled to said boom to induce a flow of fluid in said circuit in a first direction upon hoisting movement

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of said boom about said pivot, flow control means separate from said operator means and including valve means connected in said circuit to prevent fluid from flowing through said circuit in said first direction prior to the development of a preselected minimum pressure in said circuit, said valve means yielding to permit fluid to flow through said circuit in said first direction if pressure is developed in said circuit which exceeds said preselected minimum, and means coupling said flow control means to said hoisting and lowering means to be operated thereby and condition said flow control means to permit fluid to flow through said circuit in said first direction at pressures below said preselected minimum pressure when said

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hoisting and lowering means is actuated to hoist said boom.

14. A hydraulic crowd system as recited in claim 13 wherein said flow control means is coupled to said operator manipulative means of said hoisting and lowering means.

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