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Emergency control hydraulic system for a crane.

A fluid control circuit wherein said fluid is preferably a hydraulic fluid or other similar fluid, as appropriate to the application, having a variety of emergency control safety features. The fluid control system is particularly adapted for use with lifting devices, especially cranes, for loading and unloading items to or from a moving platform. This system as described is typical of that which may be used on a crane having both a main hoist and an auxiliary or whip hoist both of which are used for independent and differing load applications. The control circuit is capable of automatically setting all of the load bearing brakes upon an electrical or/and hydraulic power failure. In addition, the control circuit provides a means for an operator to release the auxiliary or whip hoist, which is the smaller load bearing hoist, in an emergency situation where the line or hook on the auxiliary or whip hoist line becomes caught on a moving object.

TECHNICAL FIELD

10 BACKGROUND ART

The fairly recent interest in offshore drilling capability has prompted a considerable investment in improving the capability and sophistication of cranes and crane systems mounted on offshore drilling platforms. Along with these investments and resulting advances in the technology and sophistication there has been a complementary increase in governmental interest in providing and ensuring for the safe operation of such sophisticated crane equipment and for the safety of the individuals operating and working around such crane systems. Such governmental interest has produced a large amount of regulation concerning the proper design of the crane systems and the proper design of control means in the event of certain types of potentially hazardous failures. One of the more extensive sets of regulations that have been issued by a governmental agency to date are those set out by the Norwegian Maritime Directorate (hereinafter NMD) concerning regulations for deck cranes or cranes used on offshore drilling platforms or similar structures. The most recent set of regulations issued by the NMD is titled and dated, "Regulations on deck cranes, etc. for use on board Norwegian and foreign drilling units using cranes in internal Norwegian waters, in Norwegian territorial waters and on that part of the Continental Shelf which is under Norwegian sovereignty, laid down by the Maritime Directorate on 31 January 1978 by virtue of § 2, first paragraph, of Royal Decree of 3 October 1975 relating to safety practices, etc. for exploration and drilling for submarine petroleum resources, cf. the resolution of delegation of 25 January 1978 by the Ministry of Petroleum and Energy, authorizing the

Maritime Directorate to prescribe regulations pursuant to Royal Decree of 3 October 1975, §§ 19, third, fourth, fifth, sixth and seventh paragraphs, 20, first, second and third paragraphs, 55, 59, 61, 111, first paragraph, 115 and 116". The rules listed therein
5 are applicable to any "appliances" that fit within the rather broad definition of the Rules and that are to be sold to a Norwegian national or corporation or that are intended for use in Norwegian territory which includes their offshore territorial waters. Some of the NMD regulations are directed to relatively standard types of
10 safety features. For example, in referenced NMD specification under Section 4 entitled "Methods of Calculations, design criteria/ construction requirements and materials", paragraph 5 entitled Winches, item 5.10 requires that the brake mechanisms of such
15 cranes are to be so arranged that they will automatically apply their full breaking force as rapidly as possible in case of power failure or failure in the control system. This type of fail safe brake lock-out is fairly common in the industry and is normally designed into a crane system regardless of such regulations. Furthermore, under § 5 entitled "Special Safety Equipment", paragraph
20 9 entitled "Emergency Stop Switches and Emergency Release System", item 9.1 requires that, "an emergency stop or shut down switch shall be provided close to the operator's seat. When this emergency stop switch is activated, all brakes shall immediately be fully engaged". Furthermore under § 4, paragraph 5, item 5.1 requires that "the
25 whip hoist winch on cranes used for loading and discharging supply ships, shall be equipped with a constant emergency release system with a hook capacity sufficient to keep a constant tension in the wire rope of approximately 1.5 tonnes. The emergency release system shall work under all conditions, including power failure. The
30 emergency release switch or handle shall be effectively secured against inadvertent use, and the winch shall automatically, with a soft characteristic, return to normal hoisting, braking or holding conditions when the emergency release is disconnected". Furthermore under § 4, paragraph 5, item 5.11 requires that "the brakes shall
35 be designed and constructed in such a way that it, within the shortest possible time, will be possible to lower and stop the full hook capacity manually and under full control in case of power

failure or failure in the control system. For large cranes, an alternative emergency power system, independent of the main power system, may be required". In the past, in order to comply with such regulations the normal design procedure had been to independently
5 design and pipe hydraulic systems that were capable of complying with a particular one of the several regulations. Such a design approach often resulted in an unduly complex system and was wasteful of hydraulic components and of space.

It is the primary object of the present invention to provide
10 for all of such required emergency control systems in a single hydraulic control circuit.

Other objects, advantages and applications of the present invention will become apparent to those skilled in the art of hydraulic control systems, especially as applied to the braking and control of
15 motor-operated winches for crane systems, from the following description, claims and from the accompanying drawings.

DISCLOSURE OF THE INVENTION

20 This invention provides a hydraulic control system for operation of a winding means having a drive means associated therewith. The control system comprises a means for generating hydraulic power, conduit means capable of supplying hydraulic power to the drive means, a plurality of valving means capable of
25 selectively supplying the hydraulic power to the drive means and a plurality of hand operable control means capable of effecting several operating modes of the control system by directing the hydraulic power to a select group of said conduit means and said valving means for a particular mode. One of the operating modes,
30 besides normal operation, is a mode for letting out a load on the winding means when the normal hydraulic power is lost, while controlling the speed with which the load unwinds the winding means. Additional operating modes for the control system include a means for letting out a load on the winding means when there is an
35 accidental over-load, while maintaining a substantially constant tension from the winding means to the load; and a means for letting out a load on the winding means when there is an accidental over-load

and there is total loss of normal hydraulic power.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Figure 1 is a diagrammatic schematic representation of one embodiment of the hydraulic system designed for the present invention, wherein one mode of operation, i.e. the emergency non-powered load lowering mode for the auxiliary or whip drum, is highlighted.

10 Figure 2 is a diagrammatic schematic representation of one embodiment of the hydraulic system of the present invention in which another mode, i.e. the emergency non-powered load lowering mode for the main drum, is highlighted.

15 Figure 3 is a diagrammatic schematic representation of one embodiment of the hydraulic system of the present invention wherein another mode, i.e. the emergency release with constant tension with power unit operating, is highlighted.

20 Figure 4 is a diagrammatic schematic representation of one embodiment of the hydraulic system of the present invention wherein another mode of operation is shown, i.e. the emergency release mode without power unit operating, is highlighted.

25 Figure 5 is a perspective view showing the manual system for effecting a shutdown, in the event of an emergency, in which the system is designed to automatically set all of the brakes on the crane when the system is activated by the operator. In the event of a power failure it is designed to automatically set all of the brakes on the crane.

30 Figure 6 is a diagrammatic schematic representation of the emergency shutdown of the electrical element of the emergency shutdown shown in figure 5.

 Figure 7 is a diagrammatic schematic representation of one embodiment of the hydraulic circuit for the crane emergency shutdown system, shown in perspective in figure 5.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings in detail, wherein like numerals indicate like elements throughout the several views, the present invention is shown and represented by a single hydraulic system that is only one possible embodiment of such a control system. This hydraulic system is capable of operating in several different modes: a normal control mode, an emergency non-powered load lowering mode for the main drum, an emergency non-powered load lowering mode for the auxiliary or whip drum, an emergency release mode with and without constant tension for the auxiliary or whip drum (with the addition of some valves and minor modification to the circuit the emergency release could be used for the main drum or in combination on both drums). The entire hydraulic system for the crane includes a number of components not represented in the hydraulic control system for the four modes of operation, shown in Figures 1-4, and for ease and simplification only those components of the overall crane hydraulic system necessary for the emergency control operating modes of the crane hydraulic system are referred to and shown in the following description.

The crane emergency control hydraulic system that is shown in figures 1 through 4 includes a pair of operator control elements: one for normal crane control and the other for emergency crane control, 2 pair of brakes: one for the main hoist drum, and one for the auxiliary or whip hoist drum; a pair of motors and their associates boxes: one for the main hoist drum and one for the auxiliary or whip hoist drum; a bank of four detented hand control valves for switching the crane hydraulic control system into one or another of its operating modes, a pressure make-up system for providing emergency power in the event of loss of power, such power make-up system being independent of the normal crane operating power system, and of several directional control valves controlling the direction of pressure flow generated either by the normal crane operating power system or the pressure make-up system, through the lines for effecting the different modes of operation. For simplification, the crane control system has been shown in each of its independently operating modes by highlighting those elements of the emergency

hydraulic control system that are used in each of the individual operating modes. For the purposes of this description then, the hydraulic control system will be described in terms of its several modes of operations.

5 Also, for purposes of this invention, the typical crane system is a Skagit Series Three Hundred Pedestal Crane powered by a two hundred and seventy horse power (270 h.p.) diesel engine operating at one thousand nine hundred and eighty (1980) rpm. The system could also be employed with other types of prime movers such
10 as an electric motor. The horsepower rating of the prime mover is dependent on the hoist capacity and speed. The engine supplies power to drive each of the four drive motors and their associated gear boxes, and supplies power to release the brakes associated therewith. The engine power is controlled by means of a pair of
15 operator controls that are operable in the normal crane operation condition. However, the emergency control system can be activated in any of a variety of situations. The primary purpose for engaging the emergency controls would be a loss of power, either total electrical power or a total or partial loss of hydraulic power, that
20 results in a loss of power to the hydraulic controls, or accidental overload.

 The first of the emergency control circuits to be described, the emergency non-powered load lowering system, is shown in Figures 1 and 2 for the auxiliary or whip drum and the main drum, respectively.
25 Both the main hoist drum and the auxiliary or whip hoist drum are provided with this system in order to allow the crane operator to lower a suspended load without power being supplied by the crane's diesel engine for powering the hydraulic circuitry and yet still enable the operator to handle the suspended load under full control.
30 The system provides a means for releasing the brakes for either the main hoist or the auxiliary or whip hoist, a means for controlling the speed with which the load suspended from either the main hoist or the auxiliary or whip hoist is lowered, and a means for stopping the load from lowering further, should that be necessary. The non-
35 powered load lowering system is primarily designed for operation where there is a loss of electrical power or a loss of the engine and the resulting loss of the hydraulic pressure necessary to operate

the crane hydraulic control system to lower the load in normal operation. However, use of the emergency non-powered load lowering system does require that the hydraulic motors of the main hoist or the auxiliary or whip hoist (which ever is being used) be in
5 operational condition, i.e. the shutdown emergency can not have been caused by a failure of the hydraulic motors such that they are no longer functional as motors (or as pumps in a reverse direction). Should this be the case, then the non-powered load lowering system would not be able to function as anticipated.

10 To activate the non-powered load lowering (NPLL) system the crane operator pulls one of the several detented hand valve control elements which are located in his cab console and which are positioned preferably near his right hand or within easy reach. There is a
15 separate control valve handle to operate the NPLL system for the main hoist and to operate the NPLL system for the auxiliary or whip hoist. However, the functioning of the non-powered load lowering system for each of the two modes of operation, i.e. main hoist or the auxiliary or whip hoist, is identical and many common components are used in each system. Referring to Figure 1, the operator activates the
20 auxiliary or whip hoist non-powered load lowering mode by pulling the push-pull cable that triggers detented hand valve 20. When valve 20 is repositioned to the left hand port (herein after all references to valve ports are relative to the particular drawing Figure being described) pressure from accumulator 11 will flow via line 80 into
25 line 82 and then through valve 20 and up to line 95 and 97. The accumulator pressure will then be directed via line 97 to shuttle valve 62 where it is directed via line 100 and energizes control valve 67, and to shuttle valves 38 and 39. From line 95 pressure is directed to shuttle valve 23 and then to the pilot positioning element on
30 directional control valve 28 which allows relief valve 26 to become functional at a reduced pressure by venting relief valve 26 pilot port to the cranes hydraulic reservoir 68. The pressure that is directed to shuttle valve 38 goes via line 105 to the right hand pilot control element on directional valve 37. The pressure that is
35 directed to shuttle valve 39 goes via line 106 to shuttle valve 43 and then to the right hand pilot positioning element on directional

control valve 42. It should be noted that valve 42 also serves to isolate the normal hydraulic system. Movement of valve 42 to the left serves to isolate any incoming pressure from the auxiliary or whip hoist motor. The auxiliary or whip hoist motor creates the pressure in line 117 when the brake (47) is released and speed control valve 29 is actuated by the crane operator activating the control valve 67. This forces the pressure generated by the auxiliary or whip hoist motor (when it acts as a pump due to the lowering of the load) to go via line 117 to directional control valve 37, and via line 116 to directional control valve 35, via line 113 to flow control valve 30, via line 110 to modulating directional control valve 29 and eventually via line 108 to motor 25a and thus driving pump 25b, activating the make-up pressure system. The net result is that having activated the auxiliary or whip hoist non-powered load lowering system, the precharged accumulator 11 has (a) pressurized the control valve 67; (b) isolated the auxiliary or whip hoist normal hydraulic system controls, and (c) activated a special emergency make-up oil pressure system.

The control valve is a modulating joy stick of the dead-man type having two axes of operation. For convenience in the Skagit Series 300 model crane, the joy stick control handle is located to the front and right of the operator. The joy stick control is used by the operator to release the auxiliary or whip hoist brake and to control the now non-powered crane load to lower the load at a controlled speed as determined by the crane operator's use of the joy stick. In the Series 300 Skagit Crane movement of the joy stick or operator control handle to the operator's left applies pressure to the hoist brake. Depending on the degree and the amount of movement, a variable pressure is directed to the auxiliary or whip hoist brake sufficient to release the brake. The operator therefor can start and stop load lowering as desired. Movement of the operator control handle only in a forward direction will cause an increase in speed with which the load can be lowered. Combining the two movements, or moving the operator control handle at a forty-five degree angle, the operator can thereby release the brake and also start lowering or stop lowering the load. The speed control line from valve 67, line

102, actually delivers its pressure to the left hand pilot positioning element of valve 29. This piloting allows the load induced pressure to enter line 108 and turn motor and pump 25.

Referring again to Figure 1, when the operator moves the
5 control handle of valve 67 to the left pressure is directed via line 101 to directional control valve 51, which is in its normally open position, allowing accumulator pressure to be directed through and onto line 119 and from there to shuttle valve 50. This pressure is then directed to shuttle valve 49 and then to auxiliary or whip
10 hoist brake 47 releasing the brake. The movement of the operator control handle of valve 67 forward directs pressure via line 102 to the left hand pilot positioning port of a modulating directional control valve 29. With the brake thus released and control valve 29 positioned such that line 110 enters the left hand most valve
15 position, the load is able to start lowering, causing the auxiliary or whip motor to rotate backwards and act as a pump. This load-induced flow then travels via line 117 into directional control valve 37 which has already been positioned into its right hand valve position, through the right valve position into line 116, and then to directional
20 control valve 35 which is still in its normal opened position, allowing pressure to travel directly through and onto line 113 to flow to control valve 30 and then on into and through the left hand port of directional control valve 29 and into line 108. From line 108 the pressure is directed to the make-up pump and motor 25. The incoming
25 load-induced flow is directed into the pressure port of motor 25(a) causing motor 25(a) to rotate and drive pump 25(b) which draws hydraulic fluid from the crane hydraulic reservoir 68. The pump 25b out-put pressure port is connected to the low pressure side of the auxiliary or whip hoist motor which is the suction port when the
30 motor is acting as a pump. Thus when this flow is combined with the load-induced flow which has passed through the makeup motor 25(a), output pressure and flow is sufficient to prevent the auxiliary or whip hoist motor (pump) from cavitating. Pressurized fluid is forced to travel via line 87, via line 86, via line 94 to the auxiliary or
35 whip hoist motor 45 completing the closed loop. Pressurized fluid from line 86 also flows through check valve 17 to line 80 and into

accumulator 11 or the control circuit. Any excess flow from the make-up pump and motor 25 is returned to the crane hydraulic reservoir 63 via relief valve 15.

It should be noted that the load-induced flow travels through flow control valve 30, which is set at a fixed flow and is pressure and temperature compensating to thereby limit the flow and the resulting maximum speed of the auxiliary or whip hoist drum when the auxiliary or whip hoist load is lowering. In addition, flow through the modulating directional control valve 29 is controlled directly by the crane operator via the operator control handle in the cab. The pressure signal to the left hand pilot port, piloting the valve to the right, is related to the pilot pressure which in turn is related to the degree to which the operator control handle of valve 67 is moved in the forward direction. It should also be noted that some of the flow after driving motor 25(a) may be returned to the crane hydraulic tank 68 via line 88 to relief valve 26 which is set to relieve at 250 psi, under normal circumstances. However, during the NPLL mode relief valve 26 has been set to relief at a reduced pressure of 45 psi, by the activation of directional control valve 28 by accumulator 11 pressure. This allows pressure to be relieved to the hydraulic tank 68 when the set pressure is reached.

It is therefore possible for the crane operator to control the speed with which a load is lowered to an infinite degree of variation by moving the operator control handle within the upper left hand quadrant of the operator control valve 67. To stop the load from lowering any further, the crane operator merely moves the non-powered load lowering operator control valve 67 to its normal or centered position. This movement blocks the pressure porting on the operator control and serves to relieve the pressure on the modulating valve 29 (or speed control valve 29), and the pressure on the brake 47 allowing the brake 47 to reset and stop the load from continuing to lower.

The de-activation of the non-powered load lowering system is accomplished simply by having the crane operator replace the non-powered load lowering auxiliary or whip hoist handle of detented valve 20 to its normal position. This action isolates the non-powered

load lowering system and allows the crane's normal operation to be reactivated. Therefore if power is later restored, the operator can proceed to operate the crane in a normal manner.

The design line speed for load lowering is in the range of
5 from 0 feet per minute when the brake is set to approximately 60 feet per minute as determined by the flow control valve 30. The loading required per line is approximately 1,000 pounds to provide this full line speed. Less of a load will reduce the maximum load lowering speed. The non-powered load lowering system in the Skagit 300 Series
10 Crane is designed to be capable of handling the crane's full rated capacity. The line speeds and pulls given in this paragraph are typical of the Skagit 300 Series Cranes. However, the line speeds and pulls for a NPLL system used for another model or make crane may differ considerably from the above.

15 One final element on the non-powered load lowering system is the accumulator hand pump. The accumulator is equipped with a hand pump element in order to feed pressure via line 83, through check valve 14 into line 80 and then into the accumulator. This hand pump is primarily designed to provide a pressure build-up means should
20 the pressure of the accumulator 11 be bled off prematurely.

The emergency non-powered load lowering system is also operable in a mode for operating the main hoist drum in a matter very similar to that as described above for the auxiliary or whip hoist drum. To activate this mode of the non-powered load lowering system,
25 referring to Fig. 2, the crane operator merely pulls the appropriate push-pull cable located in the cab to reposition detented valve 19 which serves a similar function to that of detented valve 20 for the auxiliary or whip hoist drum. When detented valve 19 is repositioned, the pressure flow is conducted from accumulator 11 via line 80 to
30 line 82 and into and through the left hand port of detented valve 19. The pressure is then directed into line 96 and line 98. From line 96 the pressure is ported to shuttle valve 23 on the opposite side from that of the auxiliary or whip hoist drum mode on the non-powered load lowering system. From there the pressure is directed into the left
35 hand pilot port of directional control valve 28 which allows relief valve 26 to become functional. At a reduced pressure by venting relief

valve 26 pilot port to the cranes hydraulic reservoir 68. From line 98 the pressure is ported to line 99 and to shuttle valve 62 and directional valve 37. Pressure from line 98 is directed to the left hand pilot of directional control valve 37. The pressure of line 99 is directed to the pilot port of directional control valve 51, repositioning it downward, and to shuttle valve 41 and into the left hand pilot positioning port of directional control valve 42. Pressure from line 98 is also directed to shuttle valve 62 and thence to operator control 67, activating the operator control in a manner similar to that for the auxiliary or whip hoist drum mode of the non-powered load lowering system. The operator control 67 is used in this instance in the same matter as with the auxiliary or whip hoist drum mode forward movement of the operator control handle causes an increase in the speed with which the load is lowered by directing pressure to the left hand pilot positioning port of the modulating directional (speed) control valve 29. Movement to the left of the operator control handle, directs pressure via line 101 to directional control valve 51 which is in its upper most position, directing pressure into line 120 and into shuttle valve 48 and then into main hoist brake 46. Judicious movement of the operator control handle in the upper left hand quadrant of the control allows for controlled lowering of the load on the main hoist brake in a manner similar to that for the non-powered load lowering system mode for the auxiliary or whip hoist.

The load is allowed to start lowering thus causing the main hoist motor to rotate backwards and act as a pump. This creates a load-induced flow that travels to line 118. From line 118 the load-induced flow is directed to directional control valve 42 where it is ported to a blocked passage, since directional control valve 42 has been piloted to the right thereby blocking out crane normal circuit. From line 118 the load-induced flow is directed to directional control valve 37 which has been piloted to the right allowing load induced flow to directly transmit through the left hand position and into line 116 directing the load induced flow to directional control valve 35. Valve 35 is in its normal position and the load-induced flow enters line 113 and goes to flow control valve 30. As with the auxiliary or

whip hoist non powered load lowering system, flow control valve 30 is set at a fixed flow and is pressure and temperature compensated to limit the maximum speed with which the main hoist drum is allowed to lower. From flow control valve 30, via line 110 the load-induced flow is directed to repositioned modulating directional control valve 29, i.e. the speed control valve, which has been piloted to the right allowing the load induced flow to enter into line 108 which directs it to check valve 27 where it is blocked. However, from line 108 the load-induced flow enters the pressure port on the motor causing the motor 25a to rotate and drive the pump 25b which is directly coupled to the motor 25a. The pump suction port is connected to the crane hydraulic reservoir 68 as with the auxiliary or whip hoist motor non powered load lowering mode. As the pump 25b generates additional pressure flow, the pressure flow is directed via line 87 to lines 85 and 86 and to check valve 24 where the flow is blocked. The pressure flow in line 85 is directed to and through check valve 17 and into line 80 where it combines with the pressure flow from accumulator 11. The flow in line 86 is directed to the main hoist motor 44 completing the closed loop, and line 94. The flow entering the main hoist motor 44 serves to prevent the motor 44 from cavitating and the flow in 25b line 94 is blocked at motor 45 and eventually at check valve 52. The additional flow created by motor and pump 25 when combined with the load induced flow which has passed through the make-up motor 25(a) provides enough pressure and flow to prevent the main hoist motor 44 from cavitating. Any excess flow is returned to the main crane hydraulic tank 68 through relief valve 26 and/or relief valve 15 when the relief valve settings have been reached.

Again, as with the auxiliary or whip hoist non-powered load lowering mode, to stop lowering the load the operator simply moves the non-powered load lowering operator control handle to its normal or centered position. This movement effectively blocks the pressure port on the operator control allowing the pressure on the speed control and brake release lines 101 and 102, respectively, to dump to the crane hydraulic reservoir 68. Thus removing pressure from the pilot element of the speed control valve 29 and brake valve 51

and thus allowing the main hoist brake 46 to set and stop the load from further lowering. The de-activation of the main drum non-powered load lowering mode is accomplished by simply placing the detented valve's 19 push pull handle back to its normal position.

5 This return of detented valve 19 to its original position isolates the non powered load lowering system from the crane's normal operation and when power is eventually restored the operator can proceed to operate the crane in a normal manner.

10 In addition to having the non powered load lowering system associated with the auxiliary or whip hoist there is also an emergency release system for the auxiliary or whip hoist. A situation may occur wherein the hook on the auxiliary or whip hoist might become caught or fouled on some moving object, such as a work boat or barge requiring that the auxiliary or whip hoist line
15 be effectively released in order to follow the direction of the moving object and to thereby avoid possible damage to either the moving object on which it is fouled or to the crane itself. If the hook should become so caught or fouled, the crane operator is provided an additional push pull handle for the emergency release system.
20 The crane operator pulls the push-pull handle to activate detented valve 21, as seen in Fig. 3. It should be noted that the system is designed to operate with the crane hydraulic power unit still operating in order that the system will be constant tensioning. Once the operator has activated detented valve 21, automatically a
25 preset line tension and a required line speed is maintained as the line associated with the auxiliary and whip hoist is hauled in or paid out as dictated by the requirements of the moving object to which it is caught or fouled.

30 When the operator activates the emergency control push-pull handle activating detented valve 21, the pressure that is directed from the precharged accumulator 11 and from the crane's normal control circuit pilot oil supply 103 assuming that the engine is still operating, will (a) release the auxiliary or whip hoist brake through a series of shuttle valves; (b) isolate the crane's normal
35 hydraulic speed and direction control circuit through a series of directional control valves; (c) engage the constant tension circuit,

assuming that the engine is still operable, through directional control valves; and, (d) activate or engage the make-up circuit if and when it is detected that the engine is not operable, or loss of normal systems hydraulic pressure occur as highlighted in Fig. 4.

5 It is also assumed that the operator has been working the auxiliary or whip hoist and that the hoist selector valve 150 is positioned to the auxiliary or whip hoist. In this position pilot oil from line 103 flows via line 152 through selector valve 150 via line 153 to the left hand pilot of detented valve 42 shifting it to
10 its left hand section.

 Having assumed that the operator has activated the emergency release control system by repositioning detented valve 21, pressure from the crane's normal hydraulic system, generated by the diesel engine in the Skagit Series 300 crane, is directed via line 103,
15 the pilot oil supply line, to line 104 and to check valve 18. Line 104 channels the crane's hydraulic pressure to the pilot port of directional control valve 36 repositioning valve 36 to the right. The pressure that enters check valve 18 goes into the accumulator line 80 and then, along with accumulator pressure, is directed via
20 line 80 to line 82 and thence through the repositioned detented control valve 21. The pressure flow leaving valve 21 enters line 89 where the pressure is directed to line 90, 91 and 92. Line 92 feeds the pressure flow to directional control valve 28 and to line 93. The flow from valve 28 is directed to relief valve 26, piloting the relief valve 26 to a preset relief valve. Line 93 channels the
25 crane's hydraulic pressure to shuttle valve 50 and then to shuttle valve 49 and to the auxiliary or whip hoist brake 47, releasing the brake. With the release of the hoist brake 47 the auxiliary or whip hoist line is free to follow the load of the moving object and thus
30 is able to pay out to to inhaul as required by the direction of the load of the object. In the payout mode, the auxiliary or whip hoist drum rotates backwards thus causing the auxiliary or whip hoist 45 to rotate backwards and acts as a pump thus creating its own flow and pressure. It should be noted that this load-induced flow pressure
35 generated by the auxiliary or whip hoist motor is proportional to the line tension created by the load of the moving object to which

the hoist line is fouled. This load-induced flow acts directly on the hoist pump swash plate control.

Referring back to the pressure along line 89 the pressure flow leaves detented directional control valve 21, the pressure
5 directed to line 91 is directed into the left hand position of repositioned directional control valve 36 where it is blocked. Line 91 also directs the pressure flow to the pilot port of directional control valve 35 porting it to the right, and to the pilot port of directional control valve 55 directing it to the right. The
10 pressure flow entering line 90 directs the pressure flow to directional control valves 58, 59 and 61. The pressure directed to valve 61 enters the pilot port shifting directional control valve 61 downward and allowing the control pressure on operator control 66 to dump to crane hydraulic tank 68. The pressure directed via
15 line 90 to directional control valves 58 and 59 enters the lower pilot ports on the directional control valves 58 and 59 repositioning the valves 58, 59 upwardly. Having repositioned the directional control valves 58 and 59, the crane's pilot oil supply is allowed to enter, via line 121 through the center position on torque control
20 valve 60. The center position of valve 60 is divided into lines 124 and 125 which direct the pressure flow to directional control valves 58 and 59, respectively. The pressure flow from these two lines 124 and 125 is then directed through the valves 58 and 59, respectively, to the hoist pump swash plate control 56 via lines 126 and 127,
25 respectively. The directional control valve 60 is a torque limiting valve which has been installed adjacent to the hoist pump. This valve 60 is a spool type with two pilot ports at each end, one pressure port, one tank port and two work ports. The work ports are connected to the swash plate control ports 56a and 56b on the hoist
30 pump through normally closed directional control valves 58 and 59 which are opened when the emergency release control is activated by the operator. The high pressure port of the hoist pump is connected to the lower pilot port of torque valve 60. The other two ports are ratio ports. A reduced pressure signal is connected to the ratio
35 pilot port on the in-haul or upper end of torque valve 60. Pressure reducing valve 63 has been installed to provide this reduced signal

from the crane's hydraulic control system. The other pilot ratio port, on the outhaul end of torque valve 60, is connected to the tank return circuit or to the crane hydraulic tank 68. Note that the torque valve 60 is a valve with a 16:1 ratio - the area of the piston on the ratio port which is connected to the reduced pressure ratio port is 16 times larger than the piston on the lower pilot port. This port senses the load induced pressure in line 157 and thus when the load induced pressure exceeds the predetermined reduced pressure by a factor of 16 the valve will shift and cause pressure to be directed to the opposite side of the pump swash plate causing the drum to rotate in the opposite direction allowing the line to payout, when induced pressure becomes less than 16 times the predetermined minimum pressure, the valve will shift back to the in-haul positions. Valves with different ratios are available. The actual pressure of the reduced pressure signal is determined by the minimum line tension that is required by the Norwegian Maritime Directorate or other similar governmental or commercial regulations of standards or customer request, i.e. the reduced signal to the ratio port is set at approximately 100 psi. In other words, it would take a pressure in excess of 1600 psi to cause torque valve 60 to shift. With a fixed predetermined pilot signal at one end of torque valve 60 creating an imbalance, torque valve 60 will shift to the in-haul mode and control pressure will be transmitted through directional control valve 59 to the in-haul port of the hoist pump swash plate control. This causes the pump to go into the in-haul mode. Conversely with the opposite end of torque valve 60 sensing the load-induced pressure entering via line 123 and when the load-induced pressure exceeds the predetermined pressure, torque valve 60 will shift into the opposite direction. This allows control pressure to be transmitted through the directional control valve 58 to the pay-out port of the hoist pump swash plate control thus changing the direction of flow from in-haul to payout. Constant tension is therefore achieved and the pump will follow the load in any direction automatically. The crane hydraulic system is capable of staying in this mode indefinitely or until either the auxiliary or whip hoist line is stripped from the auxiliary or whip hoist drum when the line

pay-out is greater than the line length (it should be noted that the length of line on the auxiliary or whip hoist will vary to fit the application) or the emergency situation is over and the operator deactivates the emergency release system and resets
5 detented valve 21, or the engine or prime mover is lost or alternatively another partial loss of control pressure occurs. It should be noted that to de-activate the emergency release system the operator merely waits until the auxiliary or whip hoist is in the in-haul mode. The operator then places the normal
10 crane hoist control on the in-haul position and returns the emergency release handle to its normal position. Transition to a normal operation under these conditions is designed to be smooth and to function without problems.

If the operator places the crane control system into the
15 emergency release mode, that is by repositioning hand operated detented valve 21, and if during the operation of the crane in the emergency release mode a loss of control pressure occurs, as for example from loss of the prime mover, the diesel engine, or failure or loss of power due to the failure of one of the hydraulic
20 components e.g. pump failure, or hose failure, then this loss of control pressure is immediately sensed by a series of directional control valves. Once the loss of hydraulic control pressure is sensed, as can be seen in Fig. 4, pressure from the accumulator 11 takes over and is capable of (a) maintaining pressure via shifting
25 of directional control valves and shuttle valves to keep the hoist brake released, (b) able to lock-out the constant tension circuit system, and (c) able to open the make-up circuit and allow the load-induced flow generated by the motor acting as a pump when the load is lowering after the brake is released to drive the make-up
30 circuit.

It should be noted that when the emergency release with constant tension mode has been activated and an electrical power failure only occurs, the system will continue to function. This is
35 done for safety reasons since it is assumed that the emergency release has been activated because the hook is caught or fouled. If the brakes were to set at this time the crane could become overloaded

causing damage or injury. With only a minor change, relocation of one oil supply line, the brakes would set with an electrical power loss.

5 With loss of control pressure there is no longer any hydraulic
pressure incoming through the pilot oil supply line 103 via check
valve 18 into the accumulator line 80 and from there into and through
detented directional control valve 21 via lines 80 and 82. In
addition there is no longer sufficient pressure to maintain the
piloted position of directional control valve 36 which will then
10 revert to its normal or right hand position due to its spring. When
directional control valve 36 repositions to its left allowing the
right hand port to take over, the flow from accumulator 11 is
directed via line 82 to detented hand control valve 21 into line
89. From there the pressure is directed into lines 90, 91 and 92.
15 From line 91 the pressure enters the left hand port of directional
control valve 36, instead of the right hand port of directional
control valve 36 where it would have been blocked. When such
pressure is directed to the left port it is then ducted down via
line 107 to shuttle valves 38 and 39. Shuttle valve 38 directs the
20 pressure via line 105 to the right hand pilot positioning port of
three position directional control valve 37, and shuttle 39 directs
the pressure via line 106 to shuttle valve 43 and from there to the
right hand pilot positioning port of directional control valve 42.
Shifting directional control valve 42 to its right hand position
25 insures that the load-induced pressure that is directed from
auxiliary or whip hoist motor 45 via line 117 will be blocked. The
repositioning of three-position directional control valve 37 to the
right hand port allows a load-induced flow coming via line 117 into
directional control valve 37 to enter line 116, which directs the
30 pressure to directional control valve 35. Directional control valve
35 directs the pressure into line 114 since it has been ported to
its left hand position by the accumulator 11 pressure coming from
line 91. The pressure from directional control valve 35 is directed
via line 114 and enters flow control valve 31, flow control valve 32
35 and flow control valve 33. Pressure leaving flow control valve 31
enters line 109 which directs pressure through check valve 27 and on

into line 108 to the make-up motor and pump 25. Pressure going upwardly via line 108 is blocked at the three position directional control valve or speed control valve 29, while pressure going downwardly via line 108 enters the pressure port of motor 25(a) activating the make-up pressure system. Pressure directed through flow control valves 32 and 33 eventually rejoins when lines 111 and 112 rejoin and enters into relief valve 34 which eventually ties to line 86. Once the make-up pump and motor are activated pressure is then directed from pump 25(b) via line 87 to line 86 and eventually it is joined by the combined pressure from lines 111 and 112 leaving flow control valves 32 and 33. It is then directed to the auxiliary or whip hoist motor via line 94 to prevent it from cavitating. Therefore, the sensing of the loss of control pressure has been translated and effected into the reactivation of the make-up pump and motor system 25 for maintaining the pressure necessary to keep the hoist brake released.

Since there is no longer a hydraulic pressure being generated by the prime mover, or the diesel engine in this case, there is no longer a pressure being sensed nor is there a reduced pressure from the crane hydraulic system being sensed at the respective ends of the torque valve 60. In addition, there is no longer a continuous pressure being provided via line 123 into torque valve 60 where it had been split into lines 124 and 125 and ported through directional control valves 58 and 59, respectively, for control of the inhaul and out pay of the hoist drum via the pump swash plates. However, accumulator pressure is still being maintained via line 80 and 82 through detented valve 21 to line 89 to lines 90 and 92. Pressure from line 90 splits into two sections and directs the pressure to the lower pilot ports of directional control valves 58, 59 and the pilot port of valve 61, should power return. If power does return then the directional control valves 58 and 59 are positioned to respond to the increased or reactivated pressure which would then flow as before to the swash plate of the hoist pump, valve 61 is positioned such that normal crane control functions remain locked out. Again it should be noted that each of the three flow control valves 31, 32 and 33 used in the release mode without constant

tension are installed with a fixed flow and are pressure and temperature compensated to limit the maximum speed that the auxiliary or whip hoist drum is capable of paying out, (paying out only in this instance, since there is no capability for controlling inhaul due to the loss of hydraulic power).

It should also be noted that line 92 is connected to directional control valve 28, which is normally open and hence to the pilot port of relief valve 26, thus activating relief valve 26. Further, line 92 is connected to the auxiliary or whip brake 47 through line 93 and shuttle valves 49 and 50, thus maintaining pressure on auxiliary or whip brake 47, and keeping the brake in the release mode.

In this emergency release mode without constant tension the auxiliary or whip hoist line is free to pay out as necessary, and this is dictated by the load, and it will continue to pay out until either the auxiliary or whip hoist line is stripped from the drum or the operator deactivates the emergency release mode by simply returning the emergency release control handle and hence the detented directional control valve 21 to its original position. This deactivation eliminates pressure to the hoist brake and causes the brake to set, stopping pay out. However, it should be noted that should this be accomplished without due regard for the incurred load that would be felt, then it is possible to experience damaging loads upon deactivation of the system and upon setting of the brake.

A high pressure relief valve 34 has been installed in the circuit to allow for momentary payout speeds in excess of the speeds set and normally limited by the flow control valves 31, 32 and 33. Relief valve 40 is activated when the operator selects the emergency release mode. When the load-induced flow and pressure in line 17 exceeds the relief valve 40 setting excess flow generated by the auxiliary or whip hoist motor acting as a pump will flow through relief valve 40 and discharge directly into line 86 through check valve 160 and into the low pressure port of the auxiliary or whip hoist motor 45. This bypasses the make-up circuit thus preventing auxiliary or whip hoist motor cavitation, and preventing overspeeding of the make-up pump and motor 25.

While the emergency release mode of the hydraulic circuit of the present invention has been described with and without a constant tension and has been described such that the emergency release mode is normally activated with constant tension and then only upon the emergency loss of power, it is possible to utilize the emergency release mode of the Emergency Release System directly should a loss of the engine or the loss of hydraulic control pressure occur. The operation to activate the emergency release control is as before and instead of transitioning from an emergency release mode with constant tension to one without constant tension, it immediately enters the emergency release without constant tension mode. In this instance pressure from the precharged accumulator 11 will cause the auxiliary or whip hoist to go into the emergency release mode such as described in the latter portion of the description for the Emergency Release with Constant Tension mode.

It has been assumed that the emergency release operation without power is the result of the engine not operating. The crane operator should not try to restore hydraulic power to the system until the emergency release handle has been returned to its normal position. Restoration of power while the crane is in the emergency release mode without constant tension will restore control pressure which will be sensed immediately by the directional control valve circuit causing the system to return to the emergency release mode with constant tension. If the auxiliary or whip hoist line is slack, the constant tension system will try to restore the line to the set tension as rapidly as possible. This rapid line recovery may cause a severe shock load to the crane. Thus the operator should not go back to normal operation until the hook has been freed from its caught or fouled position.

In addition to the above described safety or emergency lock-out modes, the hydraulic control system of the present invention also includes an emergency shut-down control system. This emergency shut-down control is designed to completely shut the engine (or prime mover) down and set all of the brakes on the crane when it is activated by the operator. In addition, the emergency shut-down is designed such that it automatically sets all of the brakes in the event of an

electrical power failure. However, if the non-powered load lowering or either of the emergency release system has been activated, only those systems not part of these emergency systems will be affected. These objects of the emergency shut-down system are accomplished

5 by mechanically attaching an electrical switch to the handle of the normally provided standard engine emergency shut-down control, which, in the Skagit Series 300 Crane System, is located in the crane cab adjacent to the operator's right hand. The shut-down control is mechanically attached through a push pull cable and suitable linkage

10 to a flapper valve on the engine air intake. The flapper valve is provided as standard equipment on all diesel engines, such as those used on the Skagit cranes. However, if other engines are employed in other types of cranes, then similar valves or other devices could be employed to effect the same result. The flapper valve on the

15 Skagit diesel engine must be physically reset at the engine after emergency shut-down is activated in order to restart the engine. The electrical switch is connected to a solenoid valve which is located in the crane's hydraulic control circuit.

When the emergency engine shut-down control is in the normal

20 run position, that is when the crane is operating as normally intended, the contacts on the electrical switch are closed. This completes the electrical circuit to the solenoid valve. The solenoid valve is also a part of the crane's hydraulic system along with the other emergency shut-down systems and is positioned as

25 shown in figure 7. Pilot oil is supplied from line 103 via line 163 through energized solenoid valve 200 to line 129 through valve 61 to the operator control 66.

To operate the emergency shut-down, the operator merely pulls up on handle 203, shown in perspective in figure 5. This action

30 releases the microswitch 202 shown in figure 5, shown in schematic form in figure 6, such that it opens the electrical circuit lines 170 and 171 which power solenoid 201. When solenoid 201 is de-energized valve 200 shifts to the left due to the spring return, and all hydraulic fluid directed via line 163 from the pilot oil

35 supply line 103 is directed to the blocked port of valve 200. In addition, all of the pressure available to the operator control 66

is dumped into the crane's hydraulic reservoir 68 via lines 129 and 163 which now is ported through and directed into line 204 to the crane hydraulic reservoir 68. Of course when this loss of hydraulic fluid occurs, there is no longer any available pressure or power for the controls which have been keeping the brakes open and the brakes are all automatically reset. It should be noted that with the loss of electrical power for whatever reason the same result occurs. One automatically loses energy to the solenoid 201 and hence the solenoid valve 200 shifts, dumping the available hydraulic fluid for operator control 66 to the hydraulic reservoir 68. Likewise, in the event of power failure the result of loss of control pressure or of dumping of the control power pressure to the hydraulic tank 68 will cause all of the brakes to set as with the operation of the emergency shut-down system.

The emergency shut-down system is available for use with or without either of the two modes of the emergency release systems or the two modes of the emergency non-powered load lowering systems. However, the preferred mode is that the hydraulic control circuit for the crane include all three of said circuits to maximize the safety of the crane.

Having reviewed each of these three emergency safety systems it should be apparent that the hydraulic control system for the crane is easily within compliance of the Norwegian Maritime Directorate Regulations for cranes used in Norwegian territory and in Norwegian waters for lifting vehicles and lifting devices. It should also be obvious that the hydraulic circuit is capable of passing the certification requirements of the Norwegian Government.

The above described hydraulic control circuit is but one embodiment of the type of fluid control circuit where such features as the emergency release with constant tension and the emergency non-powered load lowering system, particularly for use with a crane hoist or a crane device, could be used. However, it should be noted that various fluid control systems could be used with similar results for appropriate applications. In addition similar emergency control circuits could be used employing the benefits of the emergency release with constant tension system and the emergency non-powered

load lowering system without departing from the scope of the present invention. Further improvements, modifications and alternative applications and usage will therefore be readily apparent to those of ordinary skill in the art. Accordingly, the scope of the present invention should be considered in terms of the following claims and it is not to be limited to the detailed of the embodiment and its structure and operations, shown in the specification and drawings.

5 We claim:

CLAIMS

1. A fluid control system for operation of a winding

(b) conduit means capable of supplying said power to said drive means;

(c) a plurality of valving means capable of selectively supplying said power to said drive means; and

(d) a plurality of hand operable control means capable of effecting several operating modes of said control system by directing said power to a select group of said conduit means and said valving means for a particular mode.

2. The fluid control system of claim 1 wherein said operating modes include:

(1) a mode for normal operation;

(2) a mode for letting out a load on said winding means when the normal power is lost, while controlling the speed with which said load unwinds said winding means;

(3) a mode for letting out a load on said winding means when there is a partial loss of normal power, while maintaining a substantially constant tension from said winding means to said load;

(4) a mode for letting out a load on said winding means when there is a total loss of normal power; and

(5) a mode for disabling said means for providing power.

3. A fluid control system for operating a winding means having a drive means including a braking means associated therewith comprising:

(a) means for generating power;

- (b) means for providing auxiliary power;
- (c) conduit means capable of supplying said power to said drive means and said braking means;
- (d) a hand operable control means having one position for normal mode and one position for emergency mode, said emergency mode being adapted to let out a load on said winding means when there is a loss of normal power while still controlling the speed with which said load unwinds said winding means; and
- (e) valving means including a means for activating said brake means and a operator controller that is capable of directing said power to deactivate said brake means and to control the speed of unwinding in conjunction with a flow control valving means.

4. A fluid control system for operating a winding means having a drive means including a braking means associated therewith comprising:

- (a) means for generating power;
- (b) means for providing auxiliary power;
- (c) conduit means capable of supplying said power to said drive means and said braking means;
- (d) a hand operable control means having one position for normal mode and one position for emergency mode; and
- (e) valving means including a means for actuating said braking means and a means that is capable of directing said power to deactivate said braking means and to maintain said substantially constant tension in conjunction with a torque adjustable valving means.

5. A fluid control system for operating a winding means having a drive means including a braking means associated therewith comprising:

- (a) means for generating power;

- (b) means for providing auxiliary power;
- (c) conduit means capable of supplying said power
to said drive means and said braking means;
- (d) a hand operable control means having one position
for normal mode and one position for emergency
mode, said emergency mode being adapted to let
out a load on said winding means when there is
a total loss of normal power; and
- (e) valving means including a means for activating
said braking means and a means that is capable
of directing said power to deactivate said
braking means and to control said load unwinding
said winding means in conjunction with a
plurality of flow control valving means.

6. A hydraulic control system comprising:

- (a) a prime mover;
- (b) at least one hydraulic pump driven by said prime
mover to provide normal hydraulic power and
having an outlet;
- (c) at least one hydraulic motor having an inlet;
- (d) at least one winch driven by said motor;
- (e) conduit means connecting at least one of said
pump outlets to said motor inlets;
- (f) each of said winches having a braking means that
is normally activated to brake said winch and
prevent normal operation and that can be
deactivated by a hydraulic pressure;
- (g) conduit means connecting one of said pump outlets
to each of said braking means;
- (h) a plurality of hand operable valves each being
connected to said conduit means at a point
between said pump outlets and said motor inlets
and braking means and each having a first position
for normal mode operation and a second position
for emergency mode operation;

- (i) a means for providing auxiliary hydraulic power;
- (j) conduit means connecting said auxiliary hydraulic power to said hand operable valves; and
- (k) a plurality of directional control valves for selectively directing hydraulic power to said
5 braking means and to said motors.

7. The hydraulic control system of claim 6 wherein said
10 second position for at least one of said hand operable valves is adapted to direct said auxiliary hydraulic power to a operator control means; said operator control means being adapted to direct said auxiliary hydraulic power to at least one of said winch braking means to deactivate said braking means when there is a loss of normal hydraulic power and there is a load on said winch whereby
15 said load is allowed to move and said motor associated with said winch operates in reverse to generate hydraulic power from said motor inlet; and having conduit means connecting said motor inlet to said auxiliary hydraulic power conduit means.

20 8. The hydraulic control system of claim 6 wherein said second position for one of said hand operable valves is adapted to direct said auxiliary hydraulic power to at least one of said winch braking means to deactivate said braking means when there is a partial loss of normal hydraulic power and there is a load on
25 said winch and to selectively direct said auxiliary hydraulic power to some of said directional control valves which then redirect said hydraulic power to a torque valve for controlling the line tension between said winch and said load.

30 9. The hydraulic control system of claim 8 wherein said hand operable valve for effecting said operating mode for controlling said line tension from said winding means to said load directs said hydraulic power to a torque valve which works to maintain a substantially constant tension by engaging said winch to in-haul
35 until said tension is maintained when said load is negative and employing a switching means to provide a signal to said hydraulic

pump and motor associated with said winch whereby there is a smooth transition from out-haul to in-haul.

5 10. The hydraulic control system of claim 6 wherein said
second position for one of said hand operable valves being adapted
to direct said auxiliary hydraulic pressure to at least one of
said winch braking means to deactivate said braking means where
there is a loss of normal hydraulic pressure and there is a load
on said winch whereby said load is allowed to move and said motor
10 associated with said winch operates in reverse to generate hydraulic
power from said motor inlet.

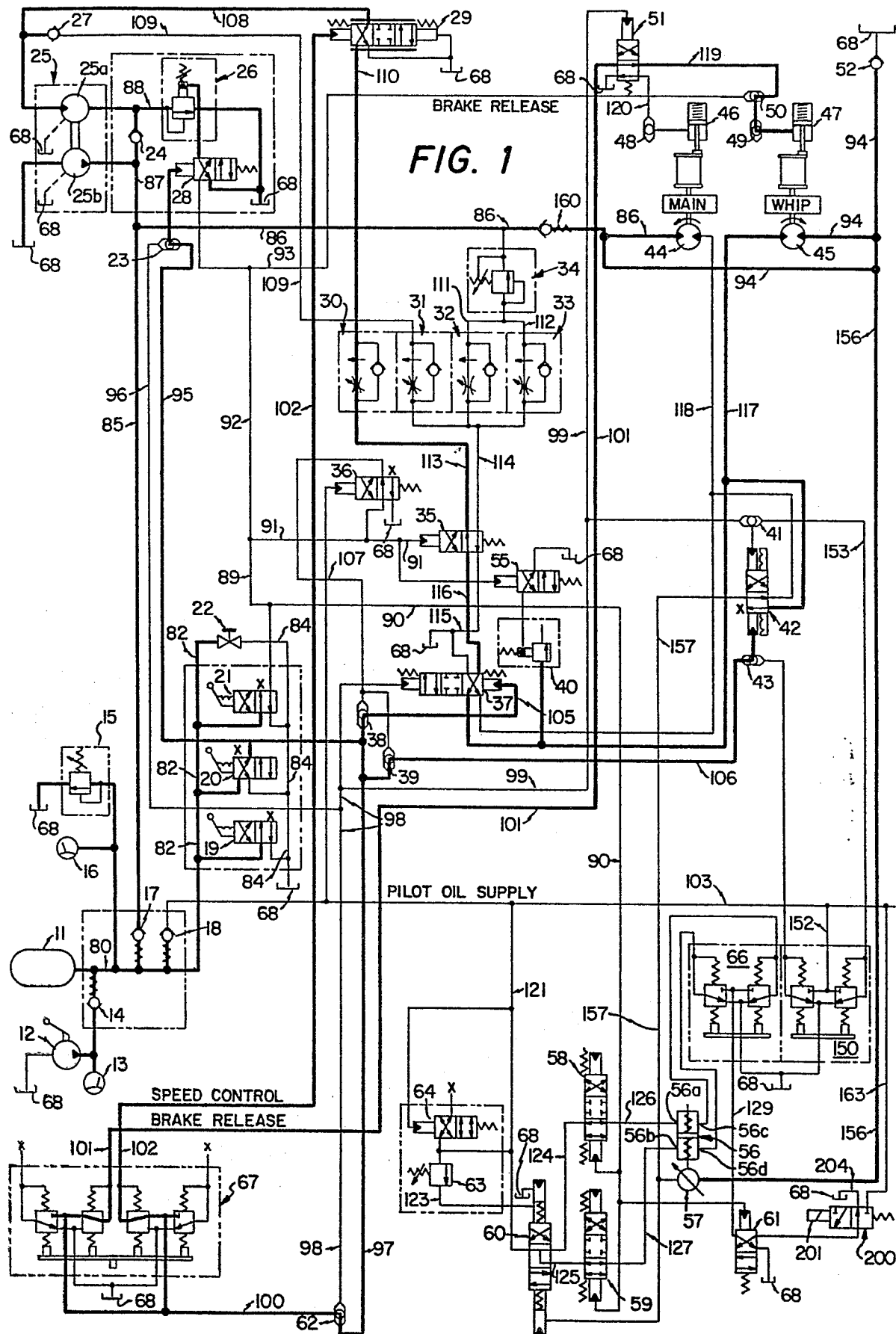
15 11. The hydraulic control system of claim 6 wherein said
second position for one of said hand operable valves being adapted
to direct said normal hydraulic power to an emergency tank and being
associated with a means for shutting down said prime mover.

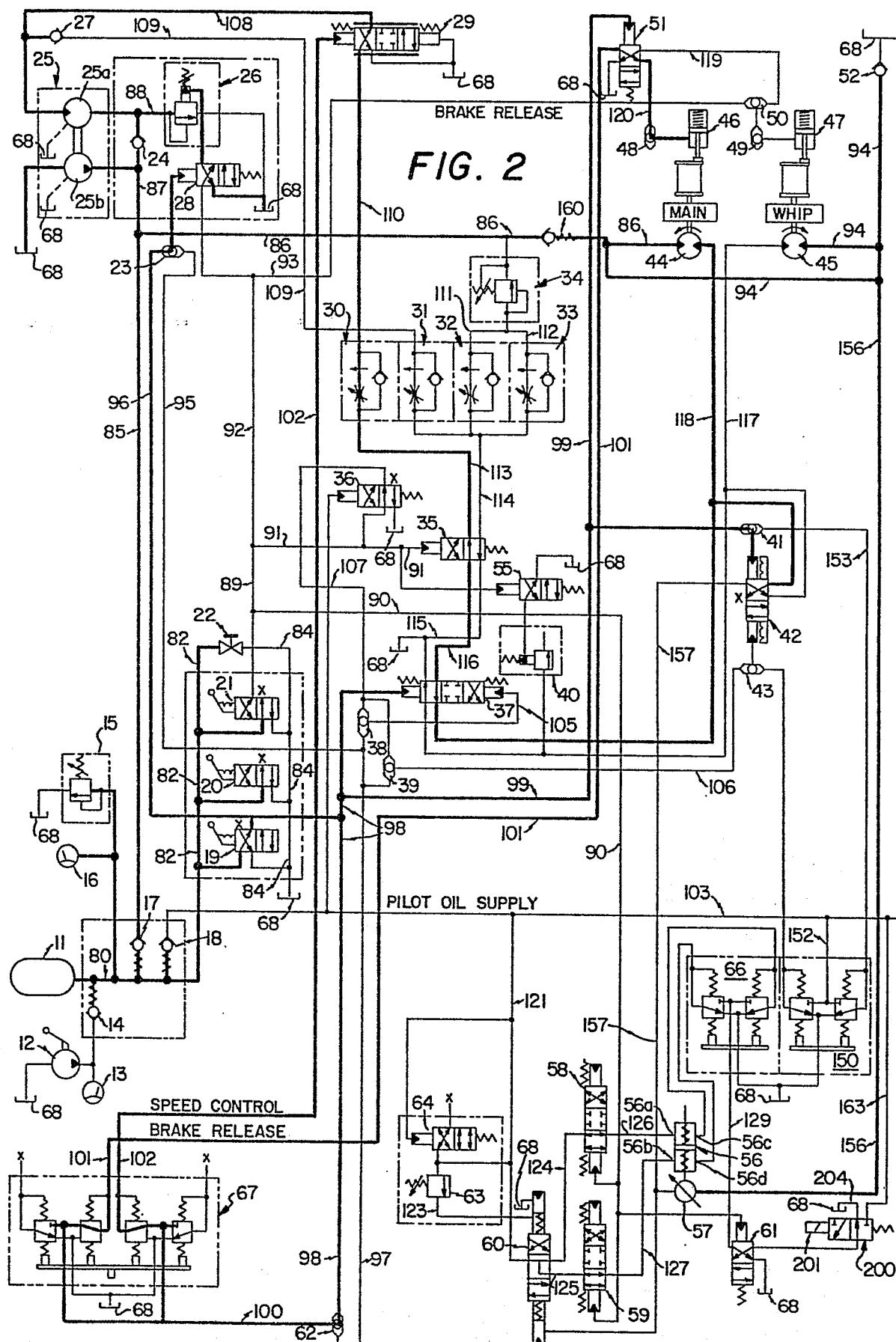
20 12. The control system of any one of claims 1 to 6 wherein
said means for generating hydraulic power is a diesel engine or an
electric motor.

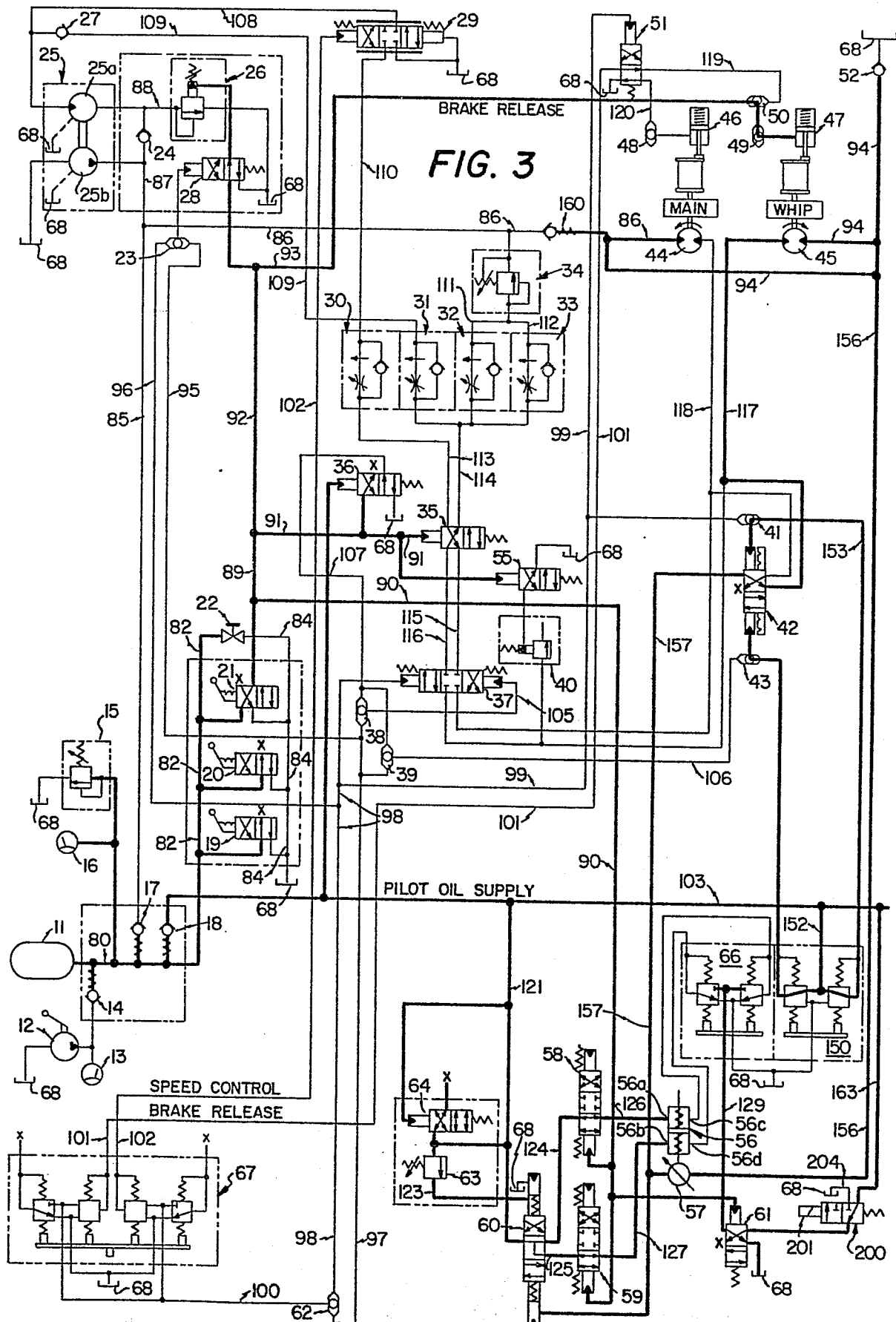
25 13. The hydraulic control system of any one of claims 1
to 6 wherein said winding means is a winch having a braking means
to activate and deactivate its normal operation.

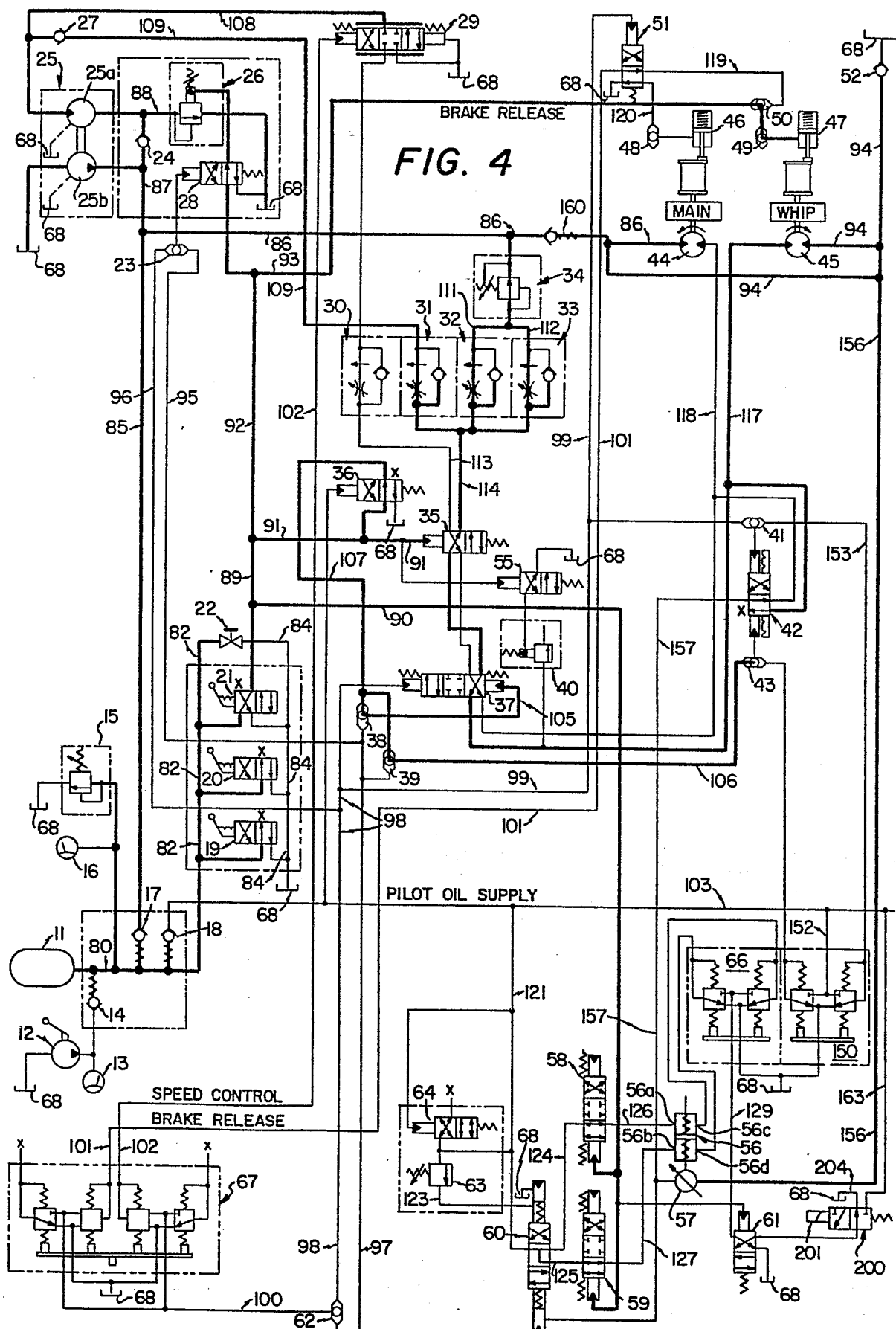
 14. The hydraulic crane system of any one of claims 1 to
6 wherein said valving means includes directional control valves,
shuttle valves and flow control valves.

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