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AUTOMATIC SWING CONTROL SYSTEM FOR DREDGE

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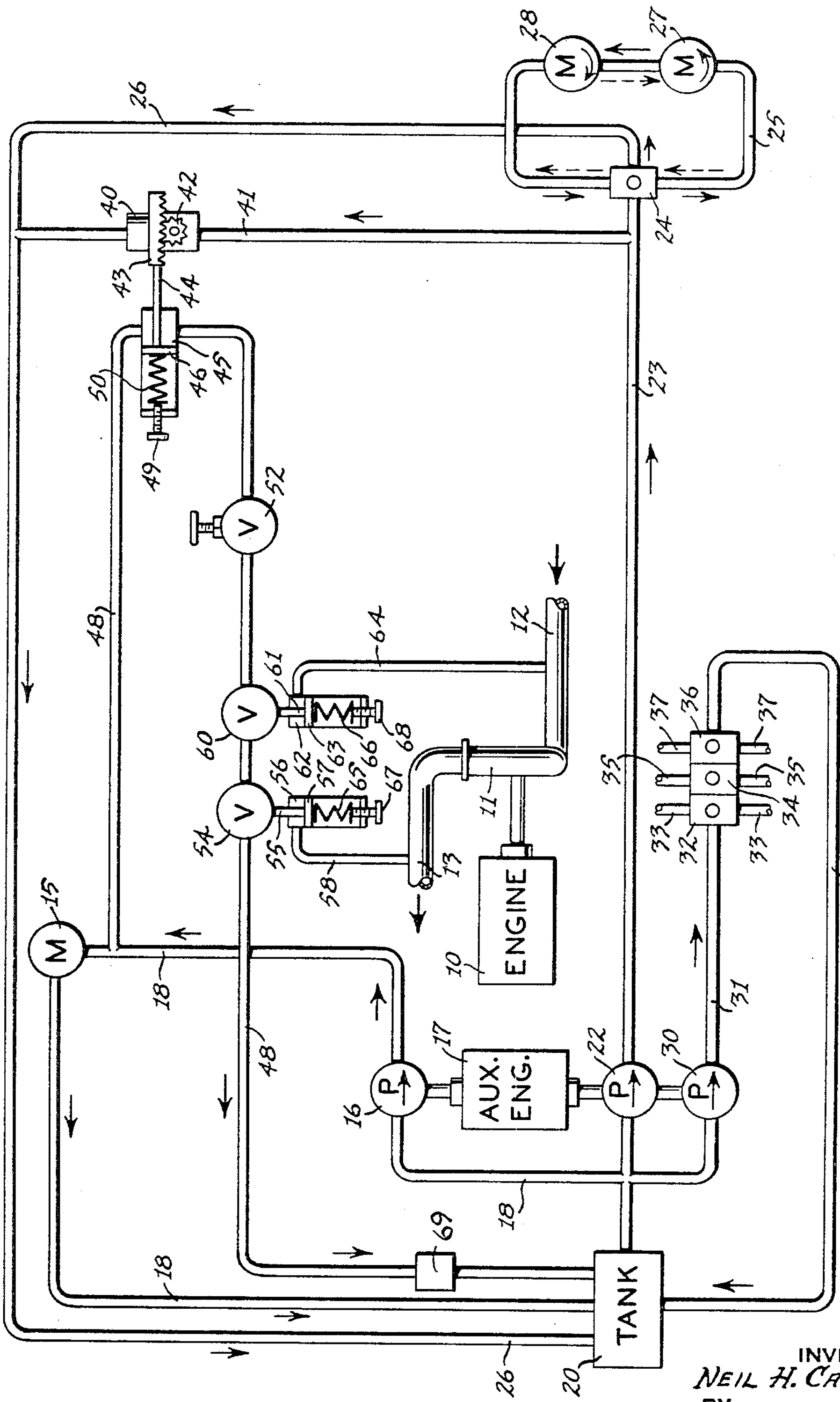

Fig. 1

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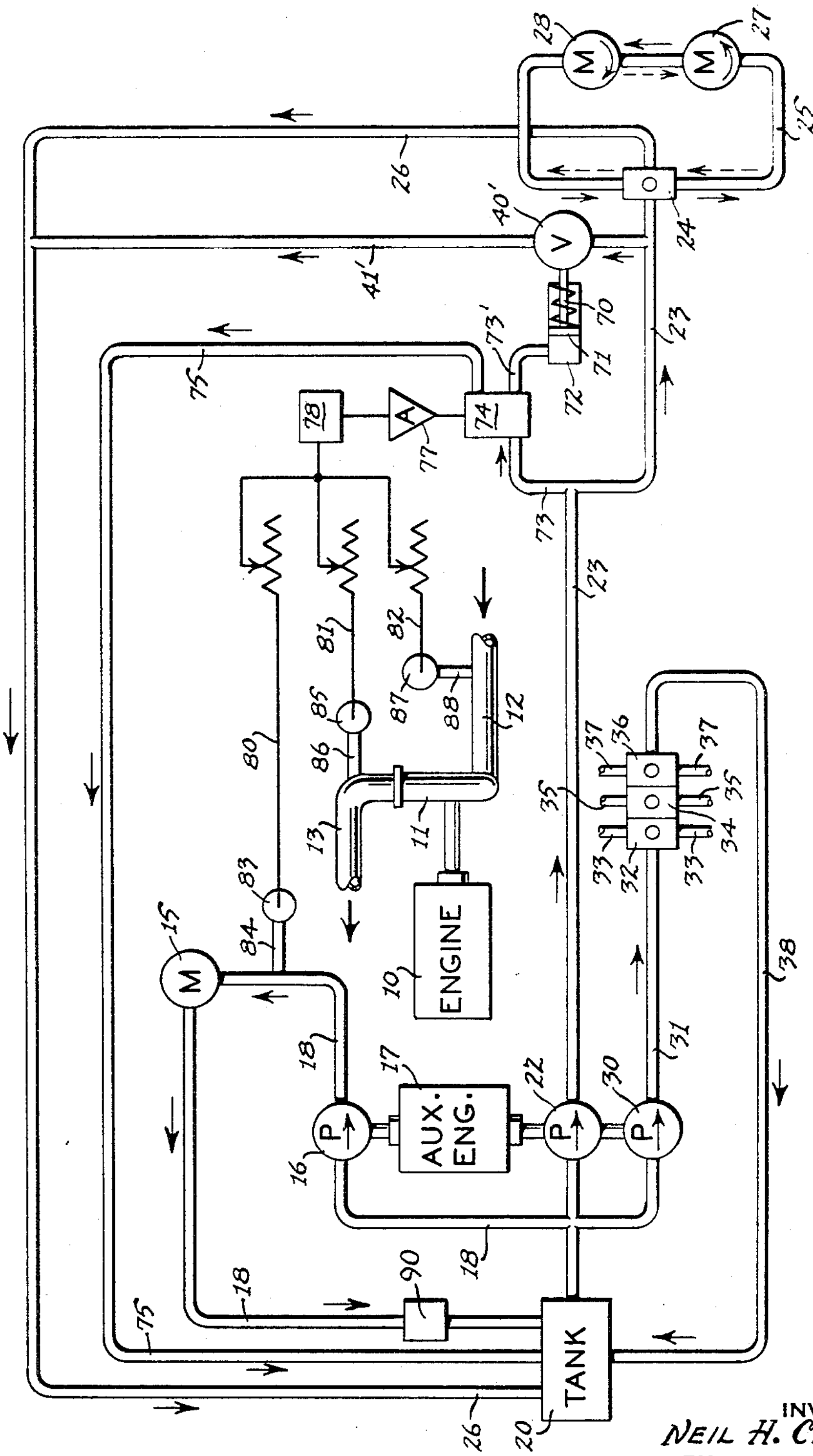

Fig. 2

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AUTOMATIC SWING CONTROL SYSTEM FOR DREDGE

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ABSTRACT OF THE DISCLOSURE

A control system for limiting the swing speed of a dredge including a variable flow control valve for varying the amount of fluid supplied to the swing motors, and a sensing system responsive to the load upon the cutter head for opening and closing the flow control valve.

BACKGROUND OF THE INVENTION

This invention relates to a fluid control for a dredge, and more particularly to an automatic control for varying the speed of the swing motors in response to the load upon the cutter head.

A hydraulic system for controlling various operations of a dredge, such as the cutter head, raising and lowering the ladder, swinging the ladder, and raising and lowering the spuds, is well known in the art. However, these various operations are controlled manualy by an operator through multiple control valves. The more experienced the operator, the better the control of the dredge. Such an operation as the control of the swinging movement of the ladder at the optimum speed for the cutter head to dig the submerged material without overloading, is a matter of both judgment and responsiveness of the operator, depending upon his aptitude and experience. Since these qualities vary from one operator to another, the efficiency as well as the durability of the dredge, and particularly the cutter head, will also vary.

In order to maintain a constant load upon the cutter head, the flow of hydraulic fluid to the swing motors, which wind and unwind cable from the swing winches in order to swing the ladder supporting the cutter head, must be varied, depending upon the resistance encountered by the cutter head. Thus, when the cutter head encounters harder material, the speed of the swing motors must be reduced to slow down the swinging movement of the ladder so that the cutter head will not become overloaded. Of course, when the cutter head encounters softer material, the speed of the swing motors should be increased to increase the swinging speed of the ladder to accommodate the capacity of the cutter head.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an automatic control system which will vary the speed of the swing motors, and consequently the swinging movement of the ladder, in order to maintain a constant load upon the cutter head regardless of the nature of the resistance which it encounters.

One object of this invention is to provide an automatic control for the swinging motors which is responsive to the pressure in the fluid circuit driving the cutter head.

Another object of this invention is to provide a system for controlling the speed of the swing motors which is responsive to the fluid pressure in the dredge pump at either its discharge or suction side, or both.

Another object of this invention is to provide an automatic control for the swinging movement of the ladder including a variable flow control valve for the swinging

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circuit which is hydraulically responsive to the fluid pressure in the cutter head circuit and/or the fluid pressure in the dredge pump.

A further object of this invention is to provide an automatic control for the swinging movement of the ladder incorporating a variable flow ccntrol valve which is actuated by an electrical system respsnive to the pressure in the cutter head circuit and/or the pressure in the dredge pump.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic flow diagram of the invention in which the automatic control of the swing circuit is hydraulic; and

FIG. 2 is a view similar to FIG. 1 in which the automatic control system is electrical.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Since the mechanical parts of a dredge, and particularly a hydraulically controlled dredge, are well-known in the art, such as that disclosed in U.S. Patent No. 3,206,875 of Neil H. Cargile, Jr., for "Hydraulic Drive Means for Dredge, Etc.," such mechanical parts have not been disclosed in the drawing, except schematically as parts of the circuit employed in this invention.

Referring now more particularly to FIG. 1, a main engine **10** drives the conventional dredge pump **11** mounted on a dredge, not shown, for pumping dredged material or spoil from the bottom of a body of water and excavated by the cutter head not shown, mounted at the remote end of the dredge ladder, not shown. The spoil is pumped through the suction pipe **12** from the vicinity of the cutter head to the dredge pump **11**, and then discharged through the discharge pipe **13** to some area remote from the dredge, usually a substantial distance beyond the stern of the dredge.

The cutter head is driven by a hydraulic cutter head motor **15** which is supplied with hydraulic fluid under pressure from pump **16** driven by auxiliary engine **17** for pumping fluid through the cutter head circuit **18**. The hydraulic fluid moves from the pump **16** through the circuit **18**, in the direction of the arrows of FIG. 1, into the intake side of the cutter head motor **15**. The spent fluid is then discharged from the discharge side of the motor **15** and returned to the tank or reservoir **20**. Fluid from the tank **20** is then supplied to the cutter head pump **16**.

Hydraulic fluid is also supplied from the tank **20** through the swing pump **22** into swing supply line **23** in the direction of the arrows, as shown in FIG. 1. The hydraulic fluid from the supply line **23** passes through a manual 4-way swing control valve **24**, which has three operative positions, forward, neutral and reverse. The valve **24** has two of its ports connected to the opposite ends of the swing circuit **25**, and another port connected to the swing return line **26**. The right hydraulic swing motor **27** and the left hydraulic swing motor **28** are connected in series in the swing circuit **25**, and are adapted to be driven in opposite directions from each other. Thus, the swing winches, not shown, will always be rotating in opposite directions to simultaneously wind one swing cable and unwind the other swing cable in order to swing the ladder laterally in one direction or the other.

When the swing control valve **24** is in neutral position, the hydraulic fluid from the pump **22** will pass directly from the swing supply line **23** through the valve **24** to return line **26** without driving the swing motors **27** and **28**. When the manual control valve **24** is moved into a forward position, the fluid from the supply line **23** passes into the swing circuit **25** in the direction of the solid-line arrows to drive the swing motors **27** and **28** in opposite directions. The fluid then passes from the swing circuit 25 back through the valve 24 and out through the return line 26 to the tank 20.

When the valve 24 is moved to its reverse position, the fluid from the swing supply line 23 passes through the valve 24 in the direction of the dashed-line arrows through the swing circuit 25 to reverse the opposite drive directions of the swing motors 27 and 28. The hydraulic fluid then passes from the swing circuit 25 through the valve 24 to the return line 26.

Instead of using two swing motors 27 and 28, a single motor may be employed to alternately drive two winches through a selective clutch mechanism in a conventional manner. Whichever winch is drivingly engaged will wind in the corresponding swing line or cable, while the non-driven winch pays out the other swing line. The non-driven winch is normally provided with braking means to eliminate slack and maintain tension in the paid out line.

Although forming no part of this invention, FIG. 1 also discloses a spud-and-ladder control circuit incorporated in a conventional dredge, and including spud pump 30, line 31, left spud valve 32, left spud control circuit 33, ladder control valve 34, ladder control circuit 35 (for raising and lowering the ladder, not shown), right spud control valve 36, right spud control circuit 37, and return line 38.

Both the swing pump 22 and the spud pump 30 are also driven by the auxiliary engine 17.

The parts thus far described are known in the art of hydraulically controlled dredges.

In accordance with this invention, a flow control valve 40 is disposed in such manner that it communicates with the swing circuit 23–26, so that the flow control valve 40 may be opened and closed to vary the amount of hydraulic fluid supplied to the swing motors 27 and 28. As disclosed in FIG. 1, the flow control valve 40 is placed in a bleeder circuit or line 41, one end of which is connected to the swing supply line 23 between the pump 22 and the manual control valve 24. The other end of the bleeder line 41 is connected to the swing return line 26. Thus, when the flow control valve 40 is open, hydraulic fluid from the pump 22 will be bled off from the swing supply line 23 to by-pass the valve 24, swing circuit 25 and swing motors 27 and 28. However, when the flow control valve 40 is closed, the operation of the swing circuit 25 will be normal, so that all the hydraulic fluid from the supply line 23 will pass through the control valve 24 and be circulated according to the position of the valve 24. Moreover, the amount of fluid passing through the swing circuit 25 may be varied by varying the position of the flow control valve 40.

As disclosed in FIG. 1, the particular embodiment of the flow control valve 40 includes a gear or pinion 42 adapted to be rotated by a meshing rack 43 so that the valve closure or gate, which is rotatable with the pinion 42, can vary between open and closed positions by the reciprocable movement of the rack 43. It will be understood of course, that other types of operator mechanisms may be employed for varying the position of the flow control valve 40.

In the embodiment of the invention as disclosed in FIG. 1, the rack 43 is fixed to a position rod 44 extending into an expansible fluid chamber 45 and fixed at one end to a piston 46, which forms one movable wall of expansion chamber 45.

The expansible fluid chamber 45 is located in a fluid control line 48, which is connected at one end to the cutter head control circuit 18 on the intake side of the cutter head motor 15. The other end of the control line 48 is connected to the tank 20.

It will thus be seen that any increase in pressure which develops on the intake side of the cutter head motor 15, such as might be caused by an overloading of the cutter head, will be transmitted to the expansion chamber 45 to move the piston 46 to the left, thereby causing the rack 43 to rotate the pinion 42 in a direction to open the flow control valve 40. The degree of movement of the valve 40, and consequently the amount of fluid passing through the bleeder line 41 to by-pass the swing circuit 25 will be a function of the fluid pressure on the intake side of the cutter motor 15 in the circuit 18.

The amount of pressure required to move the piston 46 and rotate the pinion 42 may be varied by the adjustment screw 49 and spring 50. Moreover, the fluid pressure in the line 48 may also be regulated by the manually adjustable valve 52.

It is also within the scope of this invention for the piston rod 44 responsive to the cutter head pressure in expansible chamber 45 to be operatively connected to the variable element in a variable volume swing pump 22, in order to vary the output of the pump, and consequently the speed of the winch motors 27 and 28, in response to the cutter head pressure. In this modification, the flow control valve 40 and bleeder line 41 may be omitted.

In addition to the control by the fluid pressure in the cutter head circuit 18, the swing motor speeds may also be controlled by the fluid pressure in the discharge pipe 13 and/or the fluid pressure in the suction pipe 12 of the dredge pump 11. One method of effecting this control is the installation of a two-way discharge valve 54 in the control line 48. The discharge valve 54 may be of any convenient type, such as a gate valve, operative between an open and a closed position, and normally open. The valve 54 is connected to a reciprocable piston rod 55 extending into an expansible chamber 56 affixed to a piston 57 forming the expansible wall of the chamber 56. The piston 57 is responsive to the pressure in the expansible chamber 56 which is communicated to it through pilot line 58 in fluid communication with the discharge pipe 13. Thus, when the pressure in the discharge pipe 13 is increased above its normal operating pressure, the piston 57 is moved to close the valve 54, thereby closing the line 48 to build up pressure between the valve 54 and the chamber 45, causing the piston 46 to expand and open the flow control valve 40 to bleed the swing circuit 25.

In a similar manner, a two-way, suction valve 60 is installed in the line 48 in series with the discharge valve 54. The suction valve 60 is also connected by a piston rod 61 extending into the expansible chamber 62 and terminating in the movable piston 63. Fluid pressure is transmitted from the suction pipe 12 through pilot line 64 to the expansible chamber 62. Thus, when the fluid pressure in suction pipe 12 drops below normal, or the vacuum increases, the piston 63 will be moved to close the normally open valve 60.

Springs 65 and 66 may be adjusted by the adjustable screws 67 and 68, in a manner similar to the spring 50 and adjustable screw 49 in the expansible chamber 45.

The discharge valve 54 and the suction valve 60 may also be adapted to close for either an increase or a decrease in fluid pressure in the respective discharge pipe 13 or suction pipe 12. For example, the discharge pipe 13 might be stoped up on either side of the pilot line 58 causing either an increase or decrease in pressure, depending upon the location of the obstacle. In either case, it would be desirable to slow down the speed of the swing motors 27 and 28, and thus either an increase or decrease in pressure in the expansible chamber 56 could move the valve 54 in either reciprocable direction to its closed position. Suction valve 60 could also be constructed in a similar manner.

It will thus be seen that the speed of the swing motors 27 and 28, and consequently the swinging movement of the ladder and cutter head, may be slowed down whenever there is an increase in pressure on the cutter head motor 15, or either an increase or decrease, or both, in the pressure in the dredge pump 11, either in the discharge pipe 13 or suction pipe 12. Such decreased swing speed will continue until the abnormal conditions cease, at which time the swing motors will automatically revert to normal speed.

FIG. 2 discloses a modification of this invention incorporating an electrical control system for sensing the same conditions in the same locations as sensed by the hydraulic control system of FIG. 1. All conventional parts of the circuit in FIG. 2 are identical to the conventional parts of the circuit in FIG. 1 and are identified by identical reference numbers.

The flow control valve **40'** is located in a bleeder circuit or line **41'** connected at one end to the swing supply line **23** between the manual swing control valve **24** and the swing pump **22**. The other end of the bleeder circuit **41'** is connected to the swing return line **26**, in the same manner as the bleeder circuit **41** in the hydraulic control system of FIG. 1. The flow control valve **40'** is shown as being of a slightly different construction from the flow control valve **40**, but is adapted to function in the identical manner. That is, when the flow control valve **40'** is open, fluid is by-passed from the swing supply line **23** to the return line **26** to starve the swing circuit **25** and slow down and stop the swing motors **27** and **28**.

The flow control valve **40'** may be opened and closed through a reciprocable actuator rod **70** to which is fixed a piston **71** in an expansible fluid chamber **72**. Fluid is supplied to the expansible chamber **72** from swing supply circuit **23** through the branch supply circuit **73** which is controlled by an electrical servo valve **74** of any conventional type. The servo valve **74** is so constructed that in its open position, fluid is supplied through the branch line **73** and servo line **73'** directly into the expansible chamber **72**. However, when the servo valve **74** is closed, a spring-biased piston **71** forces fluid from the expansible chamber **72** back through servo line **73'**, valve **74** and return line **75** to the tank **20**. Thus, when the servo valve **74** is open, the piston **71** is actuated to open valve **40'**. When the servo valve **74** is closed, the piston **71** returns to its operative position to close the flow control valve **40'**.

The electrical servo valve **74** is open when energized by an electrical signal from amplifier **77** and integrator circuit **78**, which integrates one or more electrical signals from the electrical sensing circuits **80**, **81**, and **82**.

The sensing circuit **80** receives an electrical signal from a pressure-electrical transducer **83**, which is in communication through a fluid pilot line **84** with the cutter head circuit **18** on the intake side of the cutter head motor **15**. In this manner, any variation in fluid pressure on the intake side of the cutter head motor **15** will be transmitted through the pilot line **84** to energize the transducer **83** to produce an electrical signal proportionate to the value of the pressure in line **84**. The electrical signal from the transducer **83** is transmitted through the sensing circuit **80** to the integrator circuit **78**, and then amplified in amplifier **77** to energize the servo **74** sufficiently to open or close the valve **40'** commensurate with the value of the fluid pressure in the cutter head circuit **18**.

In a similar manner, a pressure-electrical transducer **85** is connected in fluid communication with the discharge pipe **13** of the dredge pump **11** through pilot line **86**. The variation in fluid pressure in discharge pipe **13**, either an increase or decrease, whichever is desired, is converted to a corresponding electrical signal in the transducer **85** and transmitted through the sensing circuit **81** to the integrator circuit **78**.

Likewise, pressure-electrical transducer **87** senses the fluid pressure in suction pipe **12** through fluid pilot line **88**, which pressure is converted to a corresponding electrical signal and also transmitted to the integrator circuit **78**.

Assuming that the swing pump **22** is a variable volume pump, the servo valve **74** may be operatively connected to the variable mechanism of the pump **22** to vary the output, and consequently the speed of the swing motors **27** and **28**, in response to the signal of the integrator circuit **78**. In such event, the flow control valve **40'** and bleeder circuit **41'** may be eliminated.

It will thus be understood that any abnormal variation in the pressure developed in the cutter head motor **15**, the discharge pipe **13** or the suction pipe **12** of the dredge pump **11**, will be converted and transmitted as a corresponding electrical signal to energize the servo valve **74** in order to open the flow control valve **40'** a corresponding amount to reduce the speed of the swing motors **27** and **28** to a value which will restore the normal operating pressure conditions at the three sensing points, that is, the cutter head motor **15**, discharge pipe **13** and suction pipe **12**.

Not only will these sensing devices for each of these three sensing points respond to an abnormal condition at any one of the points for reducing the swinging speed, but also the conditions at these three points may be, and in all likelihood will be, abnormal simultaneously, so that each sensing means may act as a check on the other. Thus, in the event of failure of one sensing means, an abnormal pressure condition will be detected by one of the other sensing means. For example, when the cutter head encounters hard material which will automatically slow down its revolutions, then it will dig less material. Since the cutter head digs less material, there will be less material to be transmitted through the suction pipe **12** and the discharge pipe **13**. Under these conditions, then all three of the sensing means should register the abnormal variations in the pressures at the cutter head motor, the discharge pipe **13** and the suction pipe **12**, simultaneously. Thus, if for example, the cutter head sensing means was inoperative, the sensing means at either the discharge pipe or the suction pipe of the dredge would register the abnormal condition resulting from the reduced amount of dredged material.

In order to regulate the amount of hydraulic fluid bled from the cutterhead circuit **18** through fluid control line **48**, a pressure compensated orifice **69** is located in the control line **48** between valve **54** and the tank **20** (FIG. 1). For the same reason, a pressure compensated orifice **90** is located in the cutter head circuit **18**, in FIG. 2, between the cutter head motor **15** and tank **20**.

The sensing chamber **45** and piston rod **44** (FIG. 1) and the servo valve **74** (FIG. 2) may also be operatively connected in the ladder control circuit **35** to raise the ladder, not shown, a limited distance to permit the pump **11** to pump clear water through the suction pipe **12** and discharge pipe **13** under abnormal suction or discharge conditions. Furthermore, the above sensing controls **44–45** and **74** may also be employed in the swing circuit and spud circuit to reverse the ladder swing and raise the spuds when the desired dredging depth is attained.

It will also be understood that the swing control valve **24** may be operated automatically, instead of manually, by various automatic control systems, such as a control system regulated by a gyrocompass with pre-set angular deviations on opposite sides of a neutral axis. By such controls, the width of cut is pre-set and the cutter head automatically traverses the arc and reverses direction at the termination of each traverse.

What is claimed is:

1. A fluid system for controlling the swing of a suction dredge having a suction system including a suction pipe, suction pump, discharge pipe, fluid cutter head motor, and cutter head motor circuit, comprising:

(a) fluid swing motor means for alternately winding and paying out the swing lines of said dredge,

(b) a fluid swing circuit for driving said swing motor means,

(c) a fluid supply line connected to said swing circuit,

(d) pump means for supplying fluid through said supply line to said swing circuit,

(e) a bleeder line connected to said supply line between said pump means and said swing circuit,

(f) a flow control valve in said bleeder line,

(g) load sensing means for sensing the load on said suction system, and

(h) actuating means responsive to said load sensing means for opening said flow control valve as the load on said suction system increases to by-pass fluid from said supply line through said bleeder line, and for closing said valve as the load on said suction system decreases to reduce the flow of fluid through said bleeder line.

2. The invention according to claim **1** in which said load sensing means comprises a fluid control line connected to said cutter head circuit and by-passing said cutter head motor, an expansible fluid chamber in said control line, said actuating means comprising an actuator connected to said expansible chamber to open said flow control valve upon expansion of said chamber and to close said valve upon contraction of said chamber.

3. The invention according to claim **2** further comprising a normally open pump valve in said control line, and fluid pressure-actuated means in fluid communication with said suction pump for closing said pump valve upon a predetermined change in fluid pressure in said suction pump to cause said expansion chamber to expand to open said flow control valve.

4. The invention according to claim **1** in which said

load sensing means comprises a pressure-electrical transducer in communication with the fluid pressure in said suction system, said actuating means being electrically operated, and an electrical circuit for transmitting the resultant electrical signal from said transducer to said actuating means.

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