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(54) **HYDROSTATIC CIRCUIT FLUSHING FLOW CANCELLATION**

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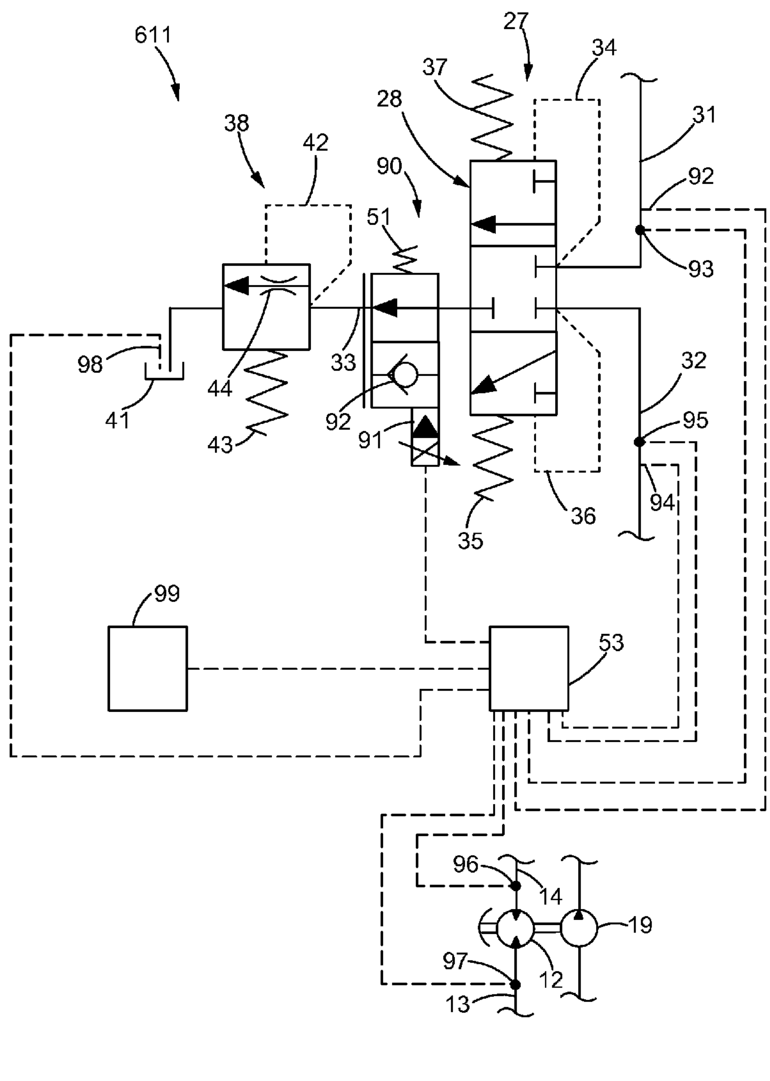
USPC **137/2**; 137/565.11

(57) **ABSTRACT**

Flushing circuits for closed loop hydrostatic circuits enable overriding of the normal function of the flushing circuit during certain machine operational events where flushing can cause undesirable performance issues. The disclosed flushing circuits may prevent flow from leaving the flush valve, may prevent flow from leaving the flushing circuit, may prevent flow from entering the flushing circuit, may prevent the flush valve from shifting from a normally closed position to an open position or may replace the hydro-mechanical control of the flush valve with an electronic control. Cancellation of the flushing function may be commanded by a controller based on fluid temperatures, pressures, turning commands, engine speed, etc.



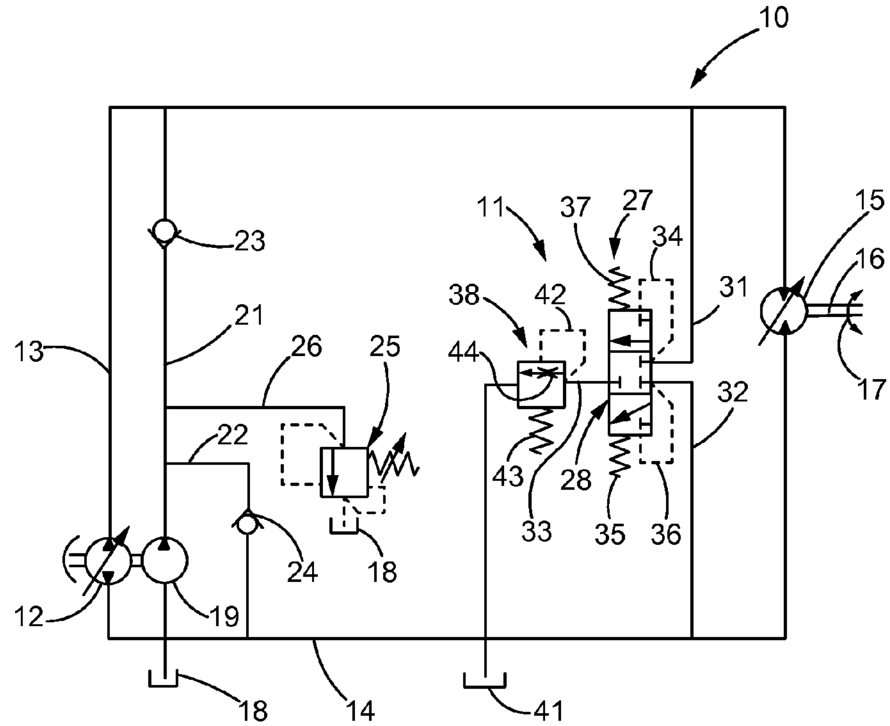


FIG. 1 (Prior Art)

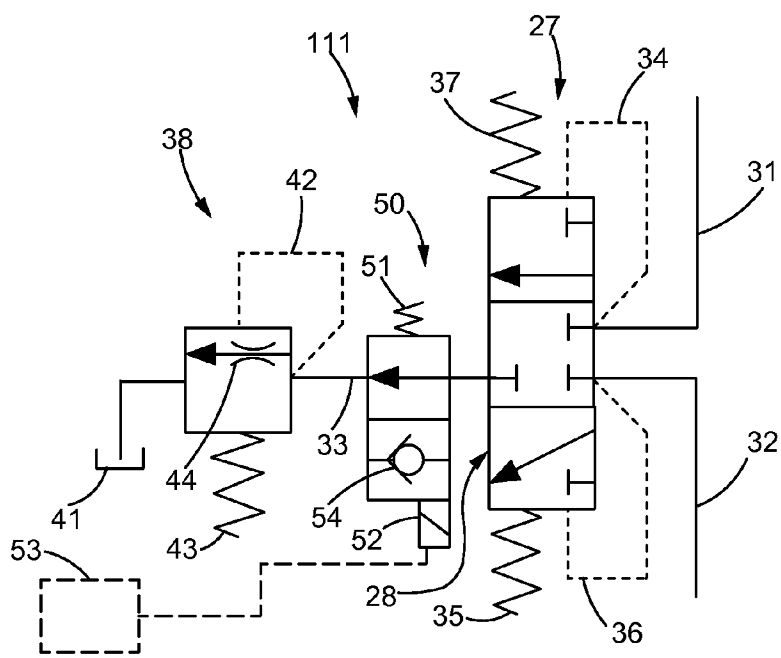


FIG. 2

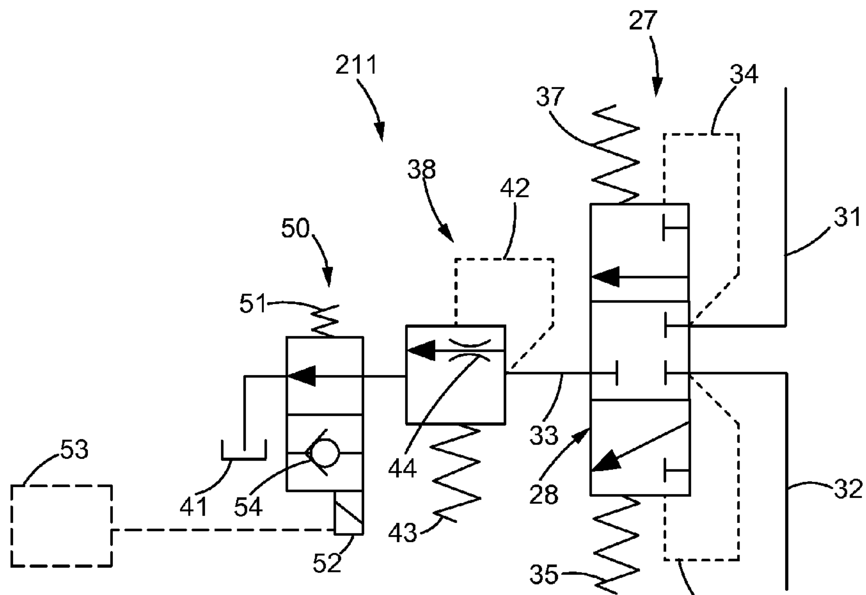

211
27
34
37
38
42
50
51
31
33
53
44
28
41
54
32
43
52
35
36

FIG. 3

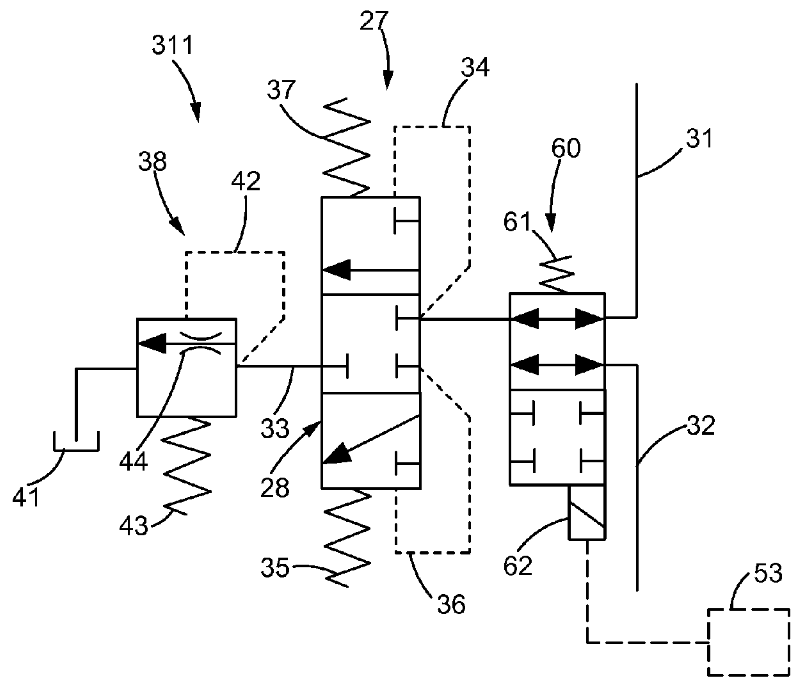

27
311
34
37
60
31
38
42
61
33
44
28
32
41
43
62
35
36
53

FIG. 4

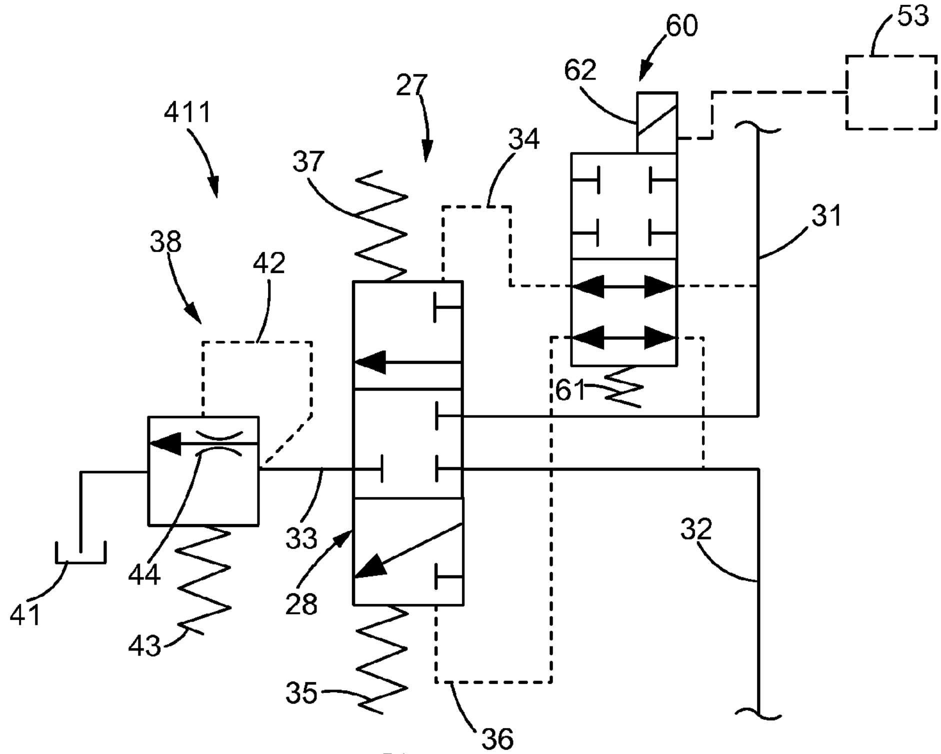

411
27
60
62
53
37
34
38
42
31
61
44
33
41
28
32
43
35
36

FIG. 5

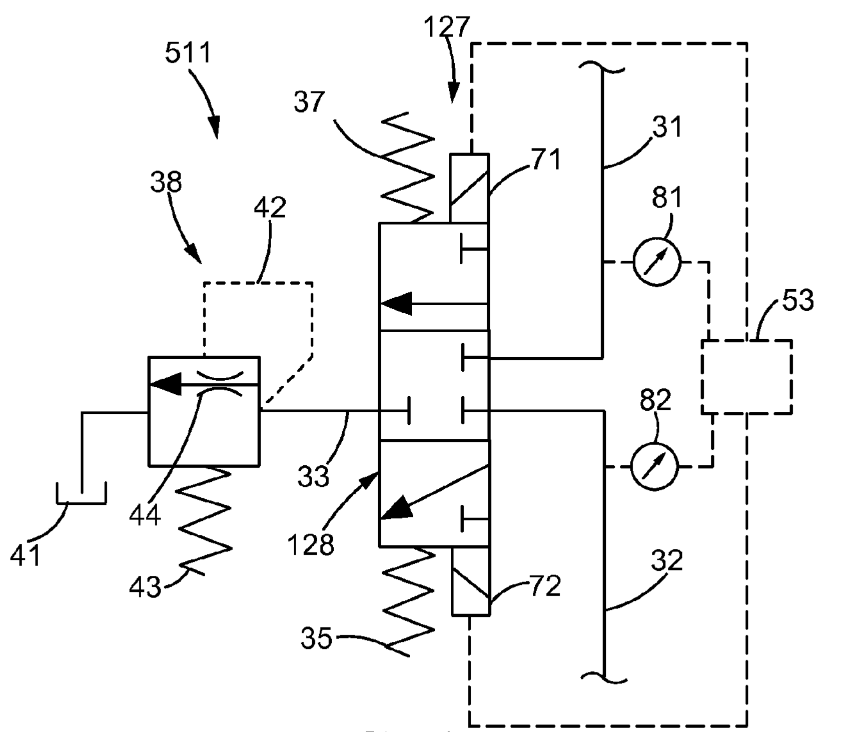

127
511
37
31
71
38
42
81
53
82
44
33
41
128
32
43
72
35

FIG. 6

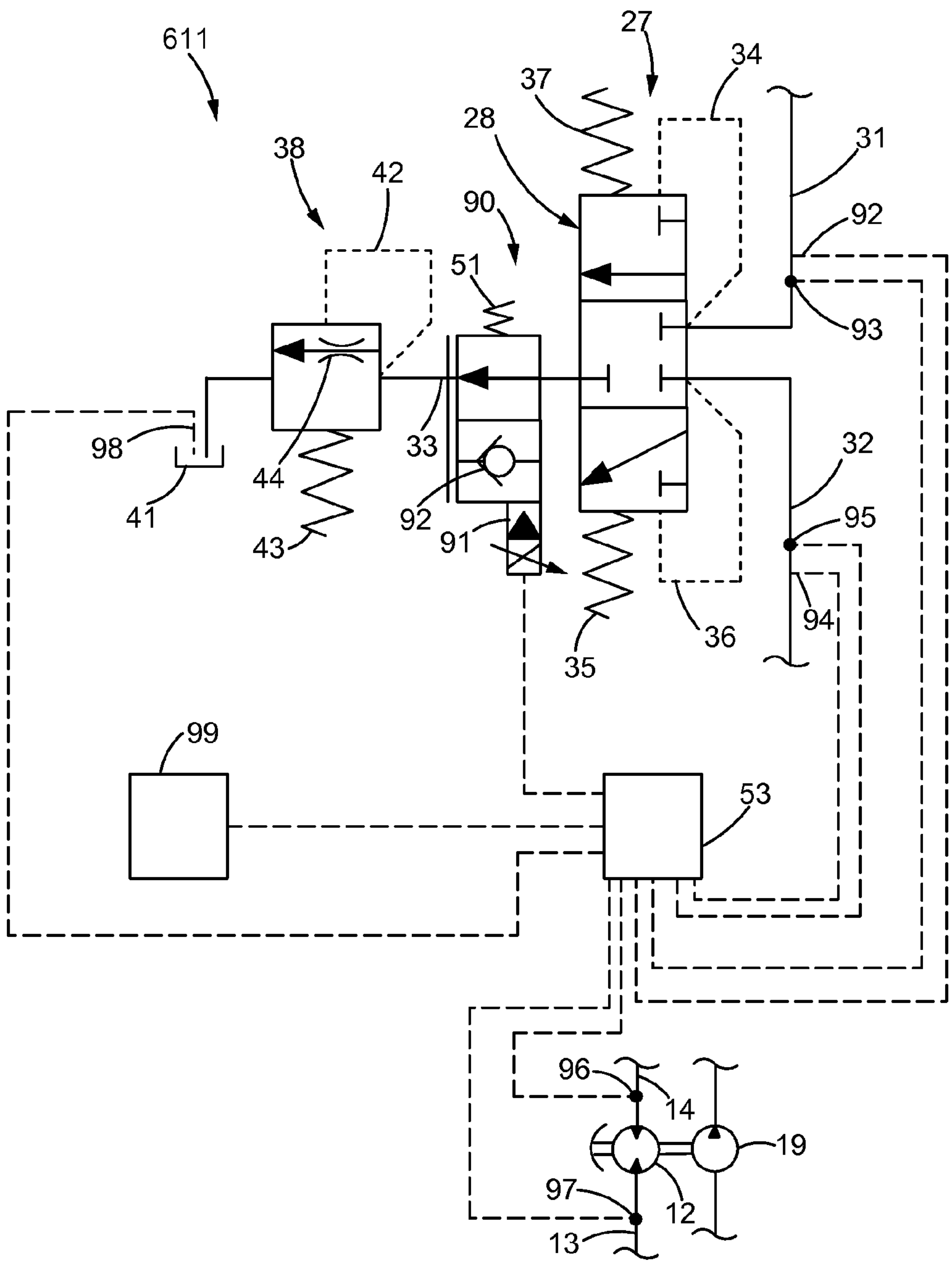

611
38
42
90
51
28
37
27
34
31
92
93
98
41
44
43
33
92
91
35
36
32
95
94
99
53
96
14
19
97
12
13

FIG. 7

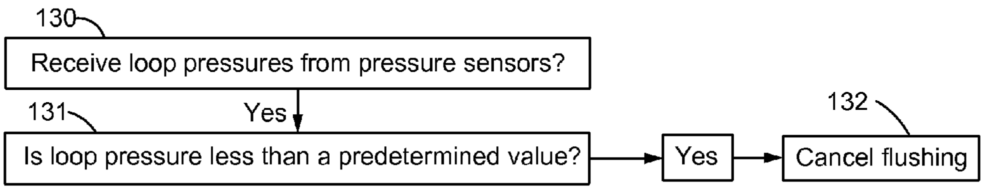


FIG. 8

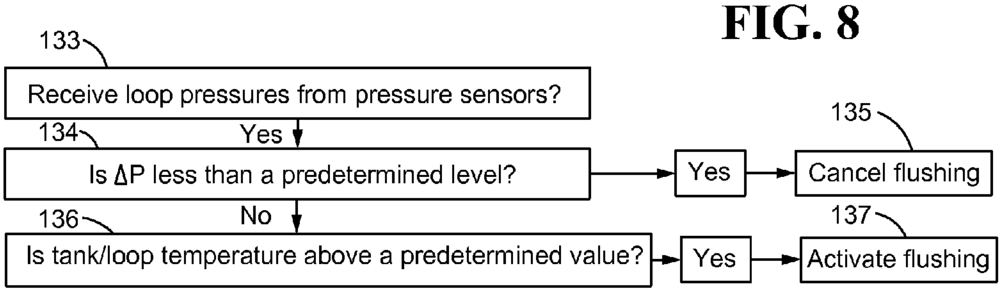


FIG. 9

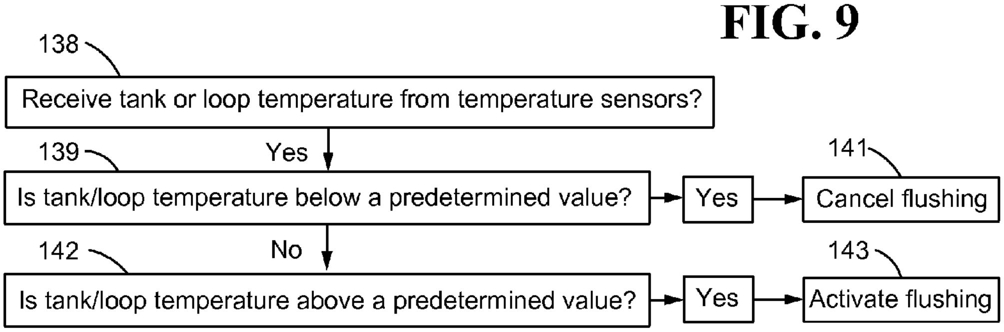


FIG. 10

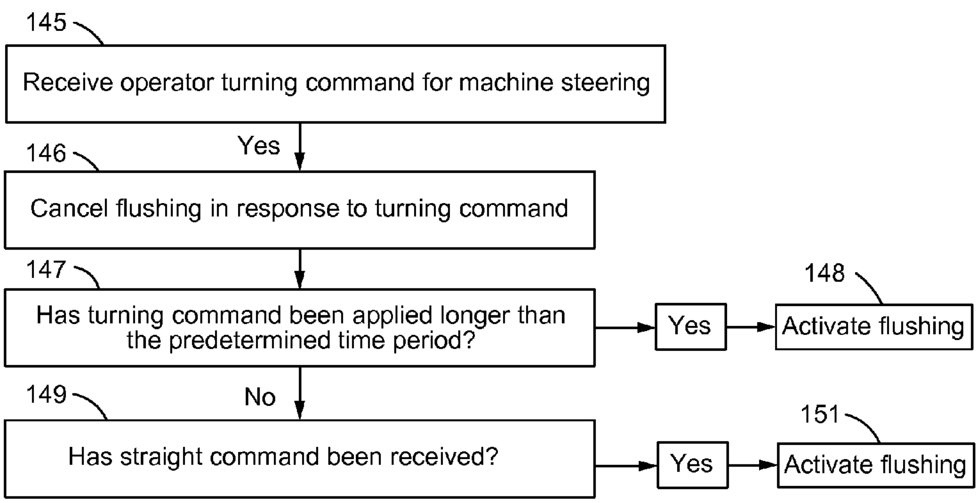


FIG. 11

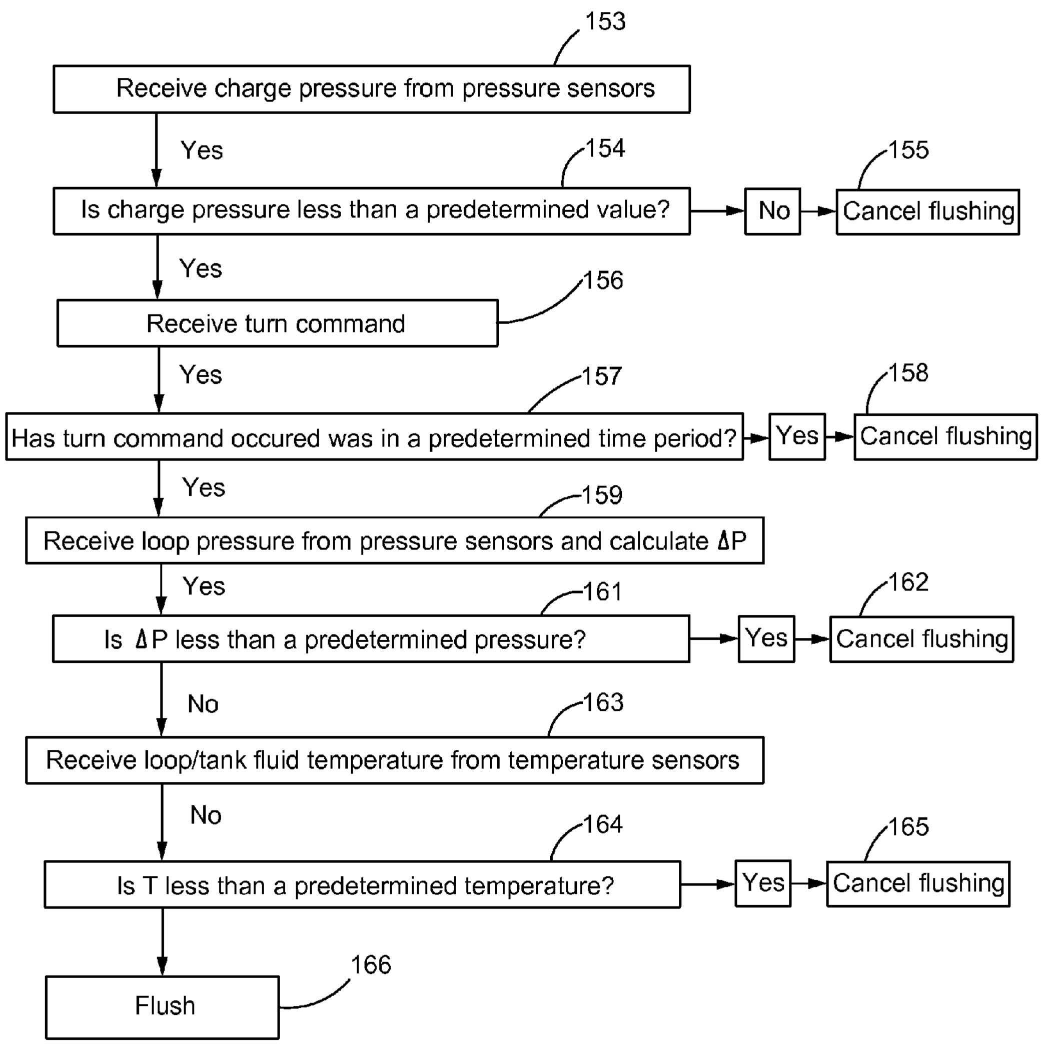

153
Receive charge pressure from pressure sensors
Yes
154
Is charge pressure less than a predetermined value?
No
155
Cancel flushing
Yes
156
Receive turn command
Yes
157
Has turn command occured was in a predetermined time period?
Yes
158
Cancel flushing
Yes
159
Receive loop pressure from pressure sensors and calculate ΔP
Yes
161
Is ΔP less than a predetermined pressure?
Yes
162
Cancel flushing
No
163
Receive loop/tank fluid temperature from temperature sensors
No
164
Is T less than a predetermined temperature?
Yes
165
Cancel flushing
166
Flush

FIG. 12

HYDROSTATIC CIRCUIT FLUSHING FLOW CANCELLATION

BACKGROUND

[0001] 1. Technical Field

[0002] This disclosure relates generally to flushing systems for hydrostatic circuits and various means for overriding such flushing systems during certain machine operational events.

[0003] 2. Description of the Related Art

[0004] In the art of hydrostatics, oil or fluid is pumped by mechanical hydrostatic pumps for the purpose of causing a hydrostatic motor to revolve, a hydrostatic cylinder to extend, or for other useful purposes. A common aspect of many tractors, earthmoving machines and the like is a hydrostatic transmission. In its most basic form, a hydrostatic transmission consists of a hydrostatic pump which is normally driven by an internal combustion engine, and provides a source of pressurized fluid flow which causes one of more hydrostatic motors to rotate. The rotation of these one or more hydrostatic motors will cause the machine to travel forward or reverse as commanded by the operator of the machine.

[0005] Hydrostatic transmissions typically operate in what is known as a closed loop circuit. In a closed loop circuit, pressurized fluid or oil from a hydrostatic pump flows directly (or through one or more valves) through one line and through a hydrostatic motor before the fluid is returned from the motor through a second line to the pump. The hydrostatic pump and motor are typically of the bidirectional and variable displacement type. This system is known as closed loop circuit because the fluid circulates in a closed path formed by the two lines between the pump and the motor without passing through a fluid reservoir on each pass. This closed loop circuit differs from an open loop circuit where a pump draws the fluid from a fluid reservoir and pumps the fluid through a motor before the fluid is returned to the fluid reservoir. Even in a closed circuit, a small reservoir and a charge pump are needed to collect a small amount of fluid which leaks out of the closed loop and to replace the leaked fluid so that the closed loop remains full of fluid at all times.

[0006] When a hydrostatic transmission is operated under heavy loads for an extended period of time, it is possible for the fluid to become heated to an extent which may not be desirable. This heating occurs due to friction and other processes. The fluid may degrade more quickly when maintained at excessive temperatures, thus requiring premature replacement of the fluid. Further, at elevated temperatures, hydrostatic fluid may lose certain lubricating properties including, but not limited to, viscosity. When a hydrostatic fluid loses viscosity, it compromises the fluid's ability to prevent damaging wear to the hydrostatic machinery, such as the pump, motor and valves. In order to remove hot fluid from the closed loop hydrostatic circuit, a "controlled leak" or loop-flushing system is employed to remove fluid from the closed circuit. This fluid is then cooled in a reservoir and returned to the closed circuit through the charge pump.

[0007] As shown in FIG. 2 of U.S. Pat. No. 6,430,923, a flushing system **32** may include a flush valve in the form of a spring-centered shuttle spool **34** that is connected to both the high pressure and low pressure fluid paths A, B on the closed loop hydrostatic circuit. The flush valve **34** may be configured to draw fluid from the low pressure line of the two hydrostatic circuit pressure lines A, B of the closed loop system. The flush valve **34** may be connected to a flushing flow regulator valve **36** that may be in communication with a reservoir, a cooler, motor case, etc. The flushing flow regulator valve **36** may control the release of fluid from the loop. The flushing flow regulator valve **36** may also serve to provide a minimal flushing flow of hot fluid from the loop while the charge pump **28** replaces the flushed hot fluid with cool fluid to maintain the fluid in the loop at an appropriate temperature.

[0008] Hydrostatic systems include several deficiencies. For example, current loop flushing systems that incorporate a flush valve and a relief valve are not intelligently controlled. Typically, the pressure in the high pressure fluid path dictates when flushing occurs because the system is not intelligently controlled, the loop flushing action occurs whenever the transmission is operational and cannot be overridden. During certain machine operational events, the flushing function can cause performance issues including, but not limited to jerky steering, slow steering response, reduced fluid pressure in the closed loop and sluggish transitions between forward and reverse movements.

[0009] Therefore, there is a need for an improved hydrostatic circuit with a flushing function that can be canceled or overridden to avoid the problems noted above.

SUMMARY OF THE DISCLOSURE

[0010] In one aspect, a hydrostatic circuit is disclosed that is capable of cancelling its flushing function. The disclosed circuit may include a hydrostatic pump connected to first and second input/output lines. The first and second input/output lines may be connected to a hydrostatic motor to form a loop. The circuit may also include a flush valve, a control valve and a flush outlet. The first and second input/output lines may also be connected to one of the flush valve or the control valve. The flush valve and the control valve may be configured to perform three functions including providing communication between the first input/output line and the flush outlet, providing communication between the second input/output line and the flush outlet and isolating the first and second input/output lines from the flush outlet. The circuit may also include a controller in communication with the control valve for opening the control valve and providing communication between the flush valve and the flush outlet, for closing the control valve and isolating the flush valve from the flush outlet and for reestablishing communication between the flush valve and the flush outlet.

[0011] In another aspect, a hydrostatic circuit is disclosed which is also capable of overriding or cancelling the flushing function. The disclosed circuit may include a hydrostatic pump connected to first and second input/output lines. The first and second input/output lines may be connected to a hydrostatic motor to form a loop. The first and second input/output lines may also be connected to a flush valve. The flush valve may include a spool that is moveable between a first position providing communication between the first input/output line and the flush outlet line. The spool may also be moveable to a second position providing communication between the second input/output line and the flush outlet line. Finally, the spool may be moveable to a third position wherein the flush valve isolates the first and second input/output lines from the flush outlet line. The flush outlet line may terminate at a flush outlet. The circuit may further include a controller that is linked to at least one flush override component selected from the group consisting of: a normally open solenoid control valve disposed downstream of the flush valve and upstream of the flush outlet and in communication with the controller and being moveable to a closed position for stopping flow from the flush valve to the flush outlet; a normally open solenoid control valve disposed upstream of the flush valve and in communication with the controller and being moveable to a closed position for stopping flow from the first and second input/output lines to the flush valve; a normally open solenoid control valve disposed upstream of the flush valve and in communication with the controller and being moveable to a closed position for preventing communication between the first and second input/output lines and the flush valve; and a pair of solenoids disposed at opposing ends of the flush valve and in communication with the controller for maintaining the flush valve in its normally closed position. The circuit may further include at least one temperature sensor linked to the controller for communicating a temperature of fluid in the hydrostatic circuit to the controller and a plurality of pressure sensors linked to the controller for communicating pressures in the first and second input/output lines to the controller.

[0012] In another aspect, a method for overriding a flushing function of a flush valve of a closed loop hydrostatic circuit is disclosed. The method may including overriding the flushing function in response to at least one operating condition selected from the group consisting of: measuring a temperature of a fluid in the circuit and, if the temperature of the fluid is below a predetermined temperature, sending a signal to stop any flushing flow from the circuit to a flush outlet; measuring a loop pressure of the fluid in the circuit and, if the loop pressure is below a predetermined minimum loop pressure, sending a signal to stop any flushing flow from the circuit to the flush outlet; measuring pressures in first and second input/output lines of the circuit, calculating a difference (ΔP) between the pressures in the first and second input/output lines and, if the ΔP is below a predetermined minimum ΔP, sending a signal to stop any flushing flow from the circuit to the flush outlet; receiving a turn command and sending a signal to stop any flushing flow from the circuit to the flush outlet; receiving a turn command, sending a signal to stop any flushing flow from the circuit to the flush outlet, timing a duration of the turn command and, if the duration of the turn command exceeds a predetermined maximum turning time period, sending a signal to initiate flushing flow from the circuit to the flush outlet and, optionally, receiving a straight steering command and sending a signal to initiate flushing flow from the circuit to the flush outlet in response to receiving the straight steering command.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a schematic illustration of a closed loop hydrostatic circuit equipped with a prior art flushing circuit, but which can be equipped with any of the disclosed flushing circuits.

[0014] FIG. **2** is a schematic illustration of a first disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0015] FIG. **3** is a schematic illustration of a third disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0016] FIG. **4** is a schematic illustration of a third disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0017] FIG. **5** is a schematic illustration of a fourth disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0018] FIG. **6** is a schematic illustration of a fifth disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0019] FIG. **7** is a schematic illustration of a sixth disclosed flushing circuit that may be incorporated into the hydrostatic circuit of FIG. **1**.

[0020] FIG. **8** is a flow chart illustrating the cancellation of the flush function when the loop pressure is below a predetermined value.

[0021] FIG. **9** is a flow chart illustrating the cancellation of a flushing function if a difference in pressures between the first and second input/output lines is less than a predetermined value and the activation of the flushing function when the tank/loop temperature is above a predetermined value regardless of the low pressure differential between the two input/output lines.

[0022] FIG. **10** is a flow chart illustrating the cancellation and activation of the flushing function in response to the fluid temperature.

[0023] FIG. **11** is a flow diagram illustrating the cancellation and activation of the flushing function in response to turn commands from the operator or steering mechanism.

[0024] FIG. **12** is another flow diagram illustrating the cancellation and activation of flushing in response to various parameters including charge pressure, turn commands, pressure differential between the two input/output lines, and fluid temperature.

DETAILED DESCRIPTION

[0025] FIG. **1** illustrates a closed loop hydrostatic circuit **10** for background purposes as FIG. **1** also illustrates typical flushing circuit **11**. It will be noted that the hydrostatic circuit **10** may not be the only type of hydrostatic circuit **10** that requires a flushing function. While the flushing circuits **111**, **211**, **311**, **411**, **511**, **611** illustrated in FIGS. **2**-**7** may be incorporated into the hydrostatic circuit **10** of FIG. **1**, it will be noted that the flushing circuits illustrated in FIGS. **2**-**7** are not limited to incorporation into the hydrostatic circuit **10** of FIG. **1**, but may be incorporated into other hydrostatic circuits as well.

[0026] Referring to FIG. **1**, the hydrostatic circuit **10** includes a hydrostatic charge pump **12** that is connected to a first input/output line **13** and a second input/output line **14**. The lines **13**, **14** are described as input/output lines **13**, **14** as the hydrostatic charge pump **12** illustrated in FIG. **1** is a variable displacement pump capable of directing flow in either direction, i.e., from the pump **12** through the line **13** to the hydrostatic motor **15** or from the pump **12**, through the line **14** to the hydrostatic motor **15**. Similarly, the hydrostatic motor **15** is also a two way variable displacement hydrostatic motor that may rotate a shaft or other component **16** in either direction as indicated by the arrows **17**. While the circuit **10** is described herein as a closed loop circuit, the hydrostatic fluid or oil flowing through the circuit **10** may need to be filtered or cleaned or the circuit **10** may need to be cooled by removing hot fluid and replacing the removed hot fluid with cooler fluid from a tank or reservoir **18**. The reservoir **18** is in communication with a makeup pump **19** which draws fluid from the reservoir **18** and delivers it to the input/output lines **13**, **14** via the makeup lines **21**, **22** respectively. The makeup lines **21**, **22** may be equipped with check valves **23**, **24** respectively to prevent backflow from the input/output lines **13**, **14** to the makeup pump **19**. The makeup lines **21**, **22** may also be in communication with a charge relief valve **25** that may be a normally closed, pilot operated pressure relief valve as shown and that may provide communication between the line **26** that is in communication with the makeup lines **21**, **22**, and the reservoir **18**, or an alternative tank or reservoir (not shown).

[0027] FIG. **1** also illustrates a conventional flushing circuit **11** that may include a flush valve **27** that may be pilot operated as shown with a shuttle spool **28** that may be moved between three positions. The flush valve **27** is shown in its normally closed position in FIG. **1** wherein flow from the first and second flush lines **31**, **32** to the flush outlet line **33** is blocked. In the event the pressure in the first input/output line **13** exceeds a predetermined value, the pressure will be communicated from the line **13**, through the line **31** to the first pilot line **34** which will shift the shuttle spool **28** downward in the orientation of FIG. **1** thereby overcoming the bias of the spring or biasing element **35** thereby establishing communication between the lower pressure second flush line **32** and the flush outlet line **33**. Similarly, in the event the pressure in the second input/output line **14** exceeds a certain value, that pressure will be communicated through the second flush line **32** to the second pilot line **36** which may then cause the shuttle spool **28** to be shifted upwards in the orientation of FIG. **1** thereby overcoming the bias of the spring or biasing element **37** and providing communication between the lower pressure first flush line **31** and the flush outlet line **33**. The flushing circuit **11** may also include a flush flow regulator valve **38** that may also be pilot operated and used to control the flow from the flush outlet line **33** to the flush outlet **41**. In short, if the pressure in the flush outlet line **33** exceeds a certain value, that pressure will be communicated through the pilot line **42** which causes the normally closed flush flow regulator valve **38** to be shifted to an open position thereby overcoming the bias of the spring or biasing element **43**. The flush flow regulator valve **38** may also include a flow control device **44** that may be a fixed orifice that limits the amount of flow that could be passed from the flush outlet line **33** through the flush flow regulator valve **38**. Further, because the flush flow regulator valve **38** may be pilot operated, it also acts as a low pressure relief valve that prevents flush flow to the flush outlet **41** during events that may reduce the charge pressure of the circuit **10** below a predetermined pressure value.

[0028] During certain operations of a machine or work implement in which a hydrostatic circuit **10** is incorporated, the flushing function can cause undesirable performance issues including, but not limited to jerky steering, slow steering response, loss of desired charge pressure and sluggish forward/reverse transition responses. Therefore, to avoid these problems, improved intelligently controlled flushing circuits **111**, **211**, **311**, **411**, **511**, **611** are disclosed in FIGS. **2-7** which include override components that override the normal hydro-mechanical function of the flushing circuit **11**. The disclosed flushing circuits **111**, **211**, **311**, **411**, **511**, **611** may operate in a variety of ways including, but not limited to preventing flushing flow from exiting the flush valve **27** or the shuttle spool **28**, preventing flushing flow from leaving the flushing circuit **11**, preventing flow from entering the flushing circuit **11**, preventing the shuttle spool **28** from shifting and/or electronically shifting the shuttle spool **28** as opposed to hydro-mechanically shifting the shuttle spool **28**. Various parameters for overriding the normal hydro-mechanical function of the flushing circuits **11**, **211**, **311**, **411**, **511** and **611** are discussed below in connection with FIGS. **7-12**.

[0029] Turning first to FIG. **2**, a disclosed flushing circuit **111** may include a hydro-mechanically operated flush valve **27** as illustrated in FIG. **1**. A flush valve override component is provided in the form of a control valve **50** disposed in the flush outlet line **33** and downstream of the flush valve **27**. The control valve **50** may be a normally open solenoid control valve equipped with a biasing element **51** and a solenoid **52** that is in communication with a controller **53**. As shown in FIG. **2**, the control valve **50** is moveable between two positions including the open position shown in FIG. **2** and a closed position which is achieved by the controller **53** sending a signal to the solenoid **52** thereby shifting the valve **50** upward in the orientation of FIG. **2** thereby placing the check valve **54** or other blocking element in the flush outlet line **33** to prevent or block communication between the flush valve **27** and the flush outlet **41**. When the valve **50** is de-energized, the flushing circuit **111** functions normally. When the controller **53** energizes the solenoid **52** thereby shifting the valve **50** to a closed position, the valve **50** prevents flushing flow from exiting the shuttle spool **28** and reaching the flush outlet **41**.

[0030] Turning to FIG. **3**, another flushing circuit **211** is disclosed that includes a flush valve **27** and flush flow regulator valve **38** as illustrated in FIG. **1**. In the flushing circuit **211** of FIG. **3**, the control valve **50** is disposed downstream of the flush flow regulator valve **38** or between the flush flow regulator valve **38** and the flush outlet **41**. Thus, if a two position/two way normally open solenoid valve like that shown at **50** in FIGS. **2-3** is utilized as the flush valve override component, such a control valve **50** may be disposed upstream or downstream of the flush flow regulator valve **38** as shown in FIGS. **2-3** respectively.

[0031] Turning to FIG. **4**, yet another flushing circuit **311** is disclosed that may be equipped with a flush valve **27** and flush flow regulator valve **38** as described above. Instead of the two position/two way normally open solenoid valve **50** as shown in FIGS. **2-3**, the flush valve override component of the flushing circuit **311** of FIG. **4** is a two position/four way normally open solenoid control valve **60** that may be disposed upstream of the flush valve **27**. The control valve **60** includes a biasing element **61** that maintains the valve **60** in a normally open position as shown in FIG. **4** and a solenoid **62** that may be linked to the controller **53**. When the controller **53** sends a signal to the solenoid **62**, the control valve **60** is shifted upward from the orientation of FIG. **4** to a closed position thereby blocking flow from the first and second flush lines **31**, **32** to the flush valve **27**. Thus, when the control valve **60** is de-energized, the flushing circuit **311** operates normally. When the controller **53** sends a signal to the solenoid **62**, the control valve **60** may be shifted to a closed position thereby preventing flow from the hydrostatic circuit **10** (FIG. **1**) from entering the flush valve **27**.

[0032] Turning to FIG. **5**, yet another flushing circuit **411** is disclosed that is similar to the flushing circuit **311** of FIG. **4**. Specifically, a two position/four way normally open solenoid control valve **60** is disposed upstream of the flush valve **27**, but in communication with the pilot lines **34**, **36** as opposed to the flush lines **31**, **32**. Again, the control valve **60**, when de-energized, is in the open position shown in FIG. **5**. If the pressure in the first flush line **31** exceeds a certain value, that pressure will be communicated through the open control valve **60** and through the first pilot line **34** to shift the shuttle spool **28** downward thereby establishing communication between the second flush line **32** and the flush outlet line **33** as the second flush line **32** is at a lower pressure than the first flush line **31**. Conversely, if the second flush line **32** is at a pressure that exceeds a certain value, that pressure will be communicated through the open control valve **60** and through the second pilot line **36** thereby shifting the shuttle spool **28** upward in the orientation of FIG. **5** and thereby establishing communication between the lower pressure first flush line **31** and the flush outlet line **33**. When energized by a signal being sent from the controller **53** to the solenoid **62**, the control valve **60** shifts downward in the orientation of FIG. **5** thereby blocking communication between the first and second flow lines **31**, **32** and the first and second pilot lines **34**, **36** respectively so that the normally closed flush valve **27** remains in its normally closed position as shown in FIG. **5**. Thus, the control valve **60** of the flushing circuit **411** maintains the flush valve **27** in its normally closed position when the control valve **60** is energized.

[0033] Turning to FIG. **6**, yet another flushing circuit **511** is illustrated which also acts to maintain a flush valve **127** in its normally closed position when the flushing function needs to be overridden. Specifically, the flush valve **127** of FIG. **6**, as opposed to the flush valves **27** of FIGS. **2-5**, is electrically or electronically activated as the flush valve **127** includes solenoids **71**, **72** disposed at either end of the shuttle spool **128**. The controller **53** controls the entire flushing function. That is, if pressure in the first flush line **31** exceeds a certain value, that value will be detected by the sensor **81**, communicated to the controller **53**, which will then send a signal to the solenoid **71** thereby shifting the shuttle spool **128** downward and providing communication between the lower pressure second flush line **32** and the flush outlet line **33**. Conversely, when the pressure in the second flush line **32** exceeds a certain value, it will be detected by the sensor **82**, communicated to the controller **53**, which will then send a signal to the solenoid **72** thereby shifting the shuttle spool **128** upwards and establishing communication between the lower pressure first flush line **31** and the flush outlet line **33**.

[0034] Finally, turning to FIG. **7**, another flushing circuit **611** is illustrated which includes the pilot operated flush valve **27** and the pilot operated flush flow regulator valve **38** as described above. The flush valve override component is provided in the form of a normally open proportional flow solenoid control valve **90** downstream of the flush valve **27**. It will be noted that the control valve **90** could also be disposed downstream of the flush flow regulator valve **38** as well. The controller **53** is in communication with an actuator **91** which, when fully energized, shifts the control valve **90** upward to a closed position where the check valve or other blocking element **92** blocks flow from exiting the flush valve **27**. When the actuator **91** is de-energized, the control valve **90** assumes the open position shown in FIG. **7**. Variable command current may be utilized to proportionally control the flushing flow rate based on system conditions. That is, instead of completely overriding the flushing function, the flushing flow rate may be reduced to an acceptable level which will not present the problems of jerky steering, slow steering response, low charge pressure and/or sluggish forward/reverse transition responses as discussed above. Thus, along with flow cancellation, the flushing circuit **611** includes the additional function of variable flushing flow.

[0035] Still referring to FIG. **7**, the various disclosed methods for cancelling and activating the flushing flow function will now be described. It will also be noted that the disclosed methods for cancelling and activating the flushing flow function are also applicable to the flushing circuits **111**, **211**, **311**, **411** and **511** of FIGS. **2-6**. The controller **53** may be linked to a plurality of sensors including a pressure sensor **92** that may be coupled to the flush line **31** in FIG. **7** but could also be placed in the first input/output line **13** shown in FIG. **1**. The controller **53** may also be linked to a temperature sensor **93** that is also shown coupled to the flush line **31**, but could also be disposed along the first input/output line **13** (FIG. **1**). Similarly, the controller **53** may be linked to a pressure sensor **94** that may be coupled to the flush line **32** as well as a temperature sensor **95** that may be coupled to the flush line **32**. The pressure and temperature sensors **94**, **95** could also be coupled to the second input/output line **14**. The controller **53** is also linked to pressure sensors **96**, **97**, disposed on the other side of the hydrostatic charge pump **12** for measuring the charge pressure or pressure in the first and second input/output lines **13**, **14**. Thus, pressure sensors **96**, **97** can also be used to measure loop pressure in a manner similar to the pressure sensors **92**, **94**. The controller **53** may also be linked to a temperature sensor **98** that may be coupled to the flush outlet **41** or fluid reservoir **18** for measuring the temperature of the fluid in the circuit **10** similar to the temperature sensors **93**, **95**. While three temperature sensors **93**, **95**, **98** are shown in FIG. **7**, only a single temperature sensor may be needed in a closed hydrostatic circuit like the one shown at **10** in FIG. **1**. Finally, the controller **53** is also linked to a steering mechanism **99** which communicates turn commands, forward and reverse commands and straight (no turn) commands to the controller **53**. The importance of the variables provided by the various sensors shown in FIG. **7** will be described in connection with the flow charts of FIGS. **8-12**.

[0036] Turning to FIG. **8** while still referring to FIG. **7**, at part **130**, the controller **53** may receive a pressure reading of fluid in the hydrostatic loop from one of the pressure sensors **92**, **94**, **96**, **97** or another appropriately placed pressure sensor for measuring the pressure of the fluid in the circuit **10**. After the controller **53** receives a pressure signal, the controller **53** determines whether the pressure is less than the predetermined pressure value at part **131**. If the pressure is below a predetermined value, the flushing function is cancelled at part **132**. The method illustrated in FIG. **8** may be particularly applicable when the engine speed is low thereby resulting in a low charge pressure and/or high load situations with substantial leakage of fluid. These situations can occur in certain machines such as skid steer loaders, track type loaders, various types of tractors, small wheel loaders and others. A low charge pressure can cause a work implement to pop out of a float position or a position where the implement is following the ground. Further, when the charge pressure is too low, the parking brake of certain machines may automatically be applied and, if the machine is moving, undue wear to the parking brake may occur.

[0037] Turning to FIG. **9**, a method is disclosed for cancelling flushing in the event the pressure difference (ΔP) between the first and second input/output lines **13**, **14** is too small. At part **133** the controller **53** receives pressure signals from two pressure sensors, such as the sensors **92**, **94** or the sensors **96**, **97**. At part **140**, the ΔP is circulated. At part **134**, the controller **53** determines whether the ΔP is less than a predetermined level and, if so, the flushing is cancelled at part **135**. If the ΔP is greater than the predetermined level at part **134**, the method may go on to determine whether the fluid temperature is above the predetermined level at part **136**. If so, flushing is actuated at part **137** to avoid over heating of the fluid.

[0038] Turning to FIG. **10**, a method for cancelling flushing in the event the fluid temperature is too low is disclosed. At part **138**, the controller **53** receives a temperature signal from at least one of the temperature sensors **93**, **94** or **98**. If the reservoir **18** and flush outlet **41** are in communication with one another, the temperature sensor **98** also reflects the temperature fluid passing through the makeup pump **19**. After the temperature signal is received at part **138**, the controller **53** determines whether the temperature is below a predetermined value at part **139** and, if so, flushing is cancelled at part **141**. If the fluid temperature is determined to be above a predetermined value at part **139** or part **142**, then flushing is activated at part **143**. If the temperature of the fluid in the circuit **10** is too low, it will cause slow shifting of the flushing spool and certain machines may be subject to uncommanded motion detection or, in other words, the flushing spool moves so slowly that the machine may not be able to follow an operators command quickly enough.

[0039] Turning to FIG. **11**, a method for cancelling flushing while a machine is being steered or turned is disclosed. At part **145**, the controller **53** receives a signal from the steering mechanism **99** that the operator has inputted a turning command. Flushing is then cancelled at part **146** in response to the turning command. Flushing is cancelled during turning of certain machines, such as small track type tractors and skid steer loaders, because the loss of pressure and fluid caused by flushing can cause steering hesitation or a sticking or hang up of the shuttle spool **28**. However, the controller **53** may include a timer and if the turning command has been applied longer than a predetermined time period at part **147**, flushing may be activated at part **148** to avoid overheating the fluid. If a straight command or a return to a straight pathway command has been received at part **149**, then flushing is activated at part **151**.

[0040] Turning to FIG. **12**, the controller **53** receives the charge pressure, most likely from either of the sensors **96**, **97** at part **153**. If the charge pressure is less than a predetermined minimum value at **154**, then the flushing is cancelled at **155**. If the charge pressure is sufficient, the controller **53** then checks to see whether it has received a turn command from the steering mechanism **99** at part **156**. If so, the controller **53** determines whether the steering command has been extended past a predetermined time period at part **157**. If so, flushing may be cancelled at part **158**. The loop pressures and ΔP are measured and calculated at part **159** and if the ΔP is less than a predetermined minimum value at part **161**, flushing may be cancelled at part **162**. The controller **53** then may check the fluid temperature at part **163** and if the temperature is less than a predetermined minimum value at part **164**, flushing may be cancelled at part **165**. If the temperature is of a sufficient value, then the system may be flushed at part **166** in a normal fashion. While the above method were described in connection with FIG. **7**, they are also applicable to the flushing circuits **111**, **211**, **311**, **411** and **511** as shown in FIGS. **2**-**6**.

INDUSTRIAL APPLICABILITY

[0041] As noted above, closed loop hydrostatic circuits **10** require a flushing function for purposes of maintaining clean fluid in the circuit **10**, maintaining a sufficient amount of fluid in the circuit **10** in the case of leakage, controlling circuit heat by removing hot fluid and replacing it with cooler fluid, etc. However, during certain machine operational events, automated flushing circuits like that shown at **10** in FIG. **1** can be activated and cause unwanted performance issues such as jerky steering, slow steering response, low charge pressure and sluggish responses during forward and/or reverse transitions. The disclosed flushing circuits **111**, **211**, **311**, **411**, **511**, **611** override the normal hydro-mechanical function of a typical flush valve **27**, **127** during machine operational events when flushing is not desired but which would otherwise trigger the flushing function. The disclosed flushing circuits **111**, **211**, **311**, **411**, **511**, **611** may prevent flushing flow from leaving the flush valve **27**, **127** or prevent flushing flow from leaving the flushing circuit **111**, **211**, **311**, **411**, **511**, **611** downstream of the flush valve **27**, **127**. The disclosed flushing circuits **111**, **211**, **311**, **411**, **511**, **611** may also prevent flow from entering the flushing circuit **111**, **211**, **311**, **411**, **511**, **611** or entering the flush valve **27**, **127**. The disclosed flushing circuits **111**, **211**, **311**, **411**, **511**, **611** may also prevent the flush valve **27**, **127** from shifting or the hydro-mechanical function of the typical flush valve **27** may be replaced by electronic control as shown by the flush valve **127** of FIG. **6**. Finally, in addition to flow cancellation during certain operational events, a proportional flow solenoid control valve **90** (FIG. **7**) may provide variable flushing flow control so that limited flushing can occur during machine operational events when a full flushing operation would be undesirable.

[0042] Various issues may arrive during the operation of a machine that may call for cancellation of the flushing function. For example, at slow speeds, low engine speeds, small or no load, bucking or instability may occur if the pressure difference between the first and second input/output lines **13**, **14** is not sufficient. Thus, the methods of FIGS. **9** and **12** may avoid this problem. Further, during a steering operation or a turning command, insufficient pressure may be available to move the shuttle spool **28**, **128**, causing it to hang up. This can result in a delay in the steering of the machine (e.g., causing the machine to proceed in a straight direction as opposed to the desired turn direction). Hence, the methods of FIGS. **11** and **12** may be employed to avoid these problems. Cold fluid also causes slow shifting of the shuttle spool **28**, **128** which may cause the machine to do something different than what it is being commanded to do. Thus, the methods of FIGS. **10** and **12** may avoid these problems. Further, low charge pressure can cause all sorts of problems including control pressures, and unintended application of the parking brake (not shown), thereby causing undue wear to the parking brake. Thus, the methods of FIGS. **8** and **12** may avoid these problems.

1. A hydrostatic circuit comprising:

a hydrostatic pump connected to first and second input/output lines;

the first and second input/output lines connected to a hydrostatic motor to form a loop;

a flush valve, a control valve and a flush outlet;

the first and second input/output lines also connected to one of the flush valve or the control valve, the flush valve and control valve configured to perform three functions including providing communication between the first input/output line and the flush outlet, providing communication between the second input/output line and the flush outlet and isolating the first and second input/output lines from the flush outlet;

a controller in communication with the control valve for opening the control valve and providing communication between the flush valve and the flush outlet, for closing the control valve and isolating the flush valve from the flush outlet and for reestablishing communication between one of the flush valve and the flush outlet.

2. The hydrostatic circuit of claim **1** wherein the control valve is a normally open proportional solenoid control valve.

3. The hydrostatic circuit of claim **1** further including a flush flow regulator valve disposed downstream of the flush valve.

4. The hydrostatic circuit of claim **1** further including a flush flow regulator valve disposed downstream of the control valve.

5. The hydrostatic circuit of claim **2** wherein the normally open proportional solenoid control valve is in communication with the controller and is disposed between the flush valve and the flush outlet, the normally open proportional solenoid control valve being adjustable between a fully open position providing full flow between the flush valve and the flush outlet and a fully closed position stopping flow between the flush valve and the flush outlet.

6. The hydrostatic circuit of claim **5** further including a flush flow regulator valve disposed downstream of the normally open proportional solenoid control valve.

7. The hydrostatic circuit of claim **6** wherein the flush flow regulator valve is pilot operated.

8. The hydrostatic circuit of claim **1** further comprising a temperature sensor linked to the controller for communicating a temperature of fluid in the hydrostatic circuit to the controller, and

if the temperature of the fluid is below the predetermined temperature, the controller closes the control valve, and

if the temperature of the fluid is above the predetermined temperature, the controller opens the control valve.

9. The hydrostatic circuit of claim **1** further including a first pressure sensor in the first input/output line and a second pressure sensor in the second input/output line, the first and second pressure sensors being linked to the controller, and

if a first pressure in the first input/output line and a second pressure in the second input/output line are both below a predetermined pressure, the controller closes the control valve.

10. The hydrostatic circuit of claim **1** further including a first pressure sensor in the first input/output line and a second pressure sensor in the second input/output line, the first and second pressure sensors being linked to the controller, the controller having a memory programmed to calculate differences between pressures sensed by the first and second pressure sensors and if said difference is less than about 20 bar, the controller closes the control valve.

11. The hydrostatic circuit of claim **1** wherein the controller is linked to a steering mechanism, the steering mechanism for communicating an operator command for machine steering to the controller, wherein, upon receiving an operator command for machine steering from the steering mechanism, the controller closes the control valve.

12. The hydrostatic circuit of claim **11** wherein if the steering command exceeds a predetermined time period, the controller opens the control valve.

13. The hydrostatic circuit of claim **11** wherein if the controller receives a straight command from the steering mechanism after receiving an operator command for machine steering from the steering mechanism, the controller opens the control valve.

14. The hydrostatic circuit of claim **1** wherein the flush outlet is connected to a fluid tank, the fluid tank including a temperature sensor that is linked to the controller, wherein if the temperature in the tank is below a predetermined temperature, the controller closes the control valve and if the temperature in the tank is above the predetermined temperature, the controller opens the control valve.

15. A hydrostatic circuit comprising:

a hydrostatic pump connected to first and second input/output lines;

the first and second input/output lines connected to a hydrostatic motor to form a loop;

the first and second input/output lines also connected to a flush valve, the flush valve including a spool that is moveable between a first position providing communication between the first input/output line and a flush outlet line, a second position providing communication between the second input/output line and the flush outlet line and a third position wherein the flush valve isolates the first and second input/output lines from the flush outlet line;

the flush outlet line terminating at a flush outlet;

a controller linked to at least one flush valve override component selected from the group consisting of

a normally open solenoid control valve disposed downstream of the flush valve and upstream of the flush outlet and in communication with the controller and being moveable to a closed position for stopping flow from the flush valve to the flush outlet,

a normally open solenoid control valve disposed upstream of the flush valve and in communication with the controller and being moveable to a closed position for stopping flow from the first and second input/output lines to the flush valve,

a normally open solenoid control valve disposed upstream of the flush valve and in communication with the controller and being moveable to a closed position for preventing communication between the first and second input/output lines and the flush valve, and

a pair of solenoids disposed at opposing ends of the flush valve and in communication with the controller for maintaining the flush valve in its normally closed position; and

at least one temperature sensor linked to the controller for communicating a temperature of fluid in the hydrostatic circuit to the controller, and

a plurality of pressure sensors linked to the controller for communicating pressures in the first and second input/output lines to the controller.

16. The hydrostatic circuit of claim **15** wherein the normally open solenoid control valve disposed downstream of the flush valve and upstream of the flush outlet is a normally open proportional solenoid control valve that is adjustable between a fully open position providing full flow between the flush valve and the flush outlet and a fully closed position stopping flow between the flush valve and the flush outlet.

17. The hydrostatic circuit of claim **15** further including a flush flow regulator valve disposed downstream of the flush valve.

18. The hydrostatic circuit of claim **17** wherein the override component is disposed downstream of the flush flow regulator valve.

19. A method for overriding a flushing function of a flush valve of a closed loop hydrostatic circuit, the method comprising:

overriding the flushing function in response to at least one operating condition selected from the group consisting of:

a) measuring a temperature of a fluid in the circuit,

if the temperature of the fluid is below a predetermined minimum temperature, sending a signal to stop any flushing flow from the circuit to a flush outlet,

b) measuring a loop pressure of the fluid in the circuit,

if the loop pressure is below a predetermined minimum loop pressure, sending a signal to stop any flushing flow from the circuit to the flush outlet,

c) measuring pressures in first and second input/output lines of the circuit,

calculating a difference (ΔP) between the pressures in the first and second input/output lines,

if the ΔP is below a predetermined minimum ΔP, sending a signal to stop any flushing flow from the circuit to the flush outlet,

d) receiving a turning command,

sending a signal to stop any flushing flow from the circuit to the flush outlet,

e) receiving a turning command,

sending a signal to stop any flushing flow from the circuit to the flush outlet,

timing a duration of the turning command,

if the duration of the turning command exceeds a predetermined maximum turning time period, sending a signal to initiate flushing flow from the circuit to the flush outlet,

receiving a straight steering command,

sending a signal to initiate flushing flow from the circuit to the flush outlet.

20. The method of claim **19** wherein the receiving and sending is performed by a controller.

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