



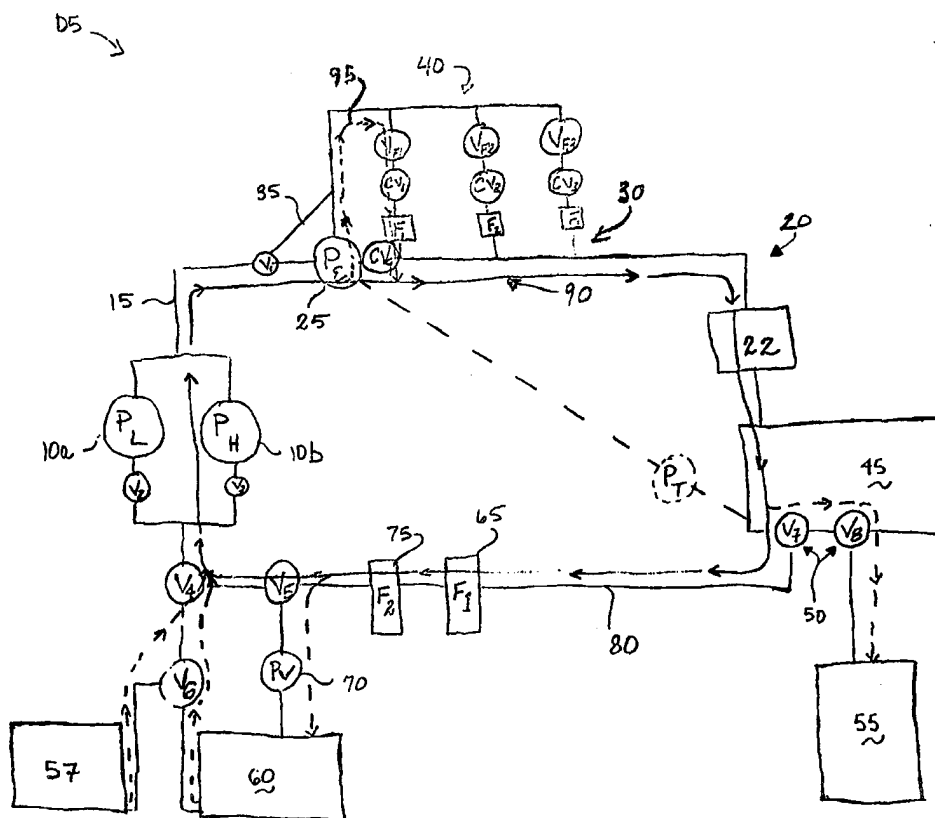
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(54) Title: METHOD FOR FLUSHING HEAVY EQUIPMENT HYDRAULIC SYSTEMS

(57) Abstract

A method for flushing a hydraulic system (20) of a heavy equipment piece. A first step of the process is to open a drain port (50) in a hydraulic system (20) of the heavy equipment piece and drain used hydraulic fluid therefrom and into a waste reservoir (55) that is maintained exterior to the equipment piece itself. A cleaning solution is then injected into the hydraulic system (20) that purges remaining undrained hydraulic fluid from the system (20) and into the waste reservoir (55). During this stage, the draining and purging fluids are monitored and it is detected when used hydraulic fluid ceases to flow from the system (20) and when cleaning solution subsequently begins to flow from the hydraulic system (20). When this situation is detected, the drain port (50) is closed and cleaning solution that continues to be injected is retained within the hydraulic system (20). The accumulated cleaning solution is ultimately evacuated from the hydraulic system (20) and fresh replenishing hydraulic fluid is injected into the hydraulic system (20). The equipment piece may then be placed back into service with fresh fluids and usually improved performance.



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METHOD FOR FLUSHING HEAVY EQUIPMENT HYDRAULIC SYSTEMS

RELATED PATENT APPLICATIONS: This patent application claims priority to
5 United States Provisional Application No. 60/027,415 filed October 8, 1996 which
is entitled AGRICULTURAL EQUIPMENT FLUSHING SYSTEM.

TECHNICAL FIELD: This invention relates generally to the maintenance of
agricultural and heavy industrial equipment; more particularly, it relates to the
10 cleaning and replacement of lubricating and operating fluids in hydraulic systems
and/or transmission systems of those types of equipment.

BACKGROUND ART: It is well known in agricultural and heavy equipment
industries that periodic maintenance is required on both hydraulic and transmission
15 systems. In each of such systems, fluids are utilized in the system's operation
that through use become contaminated and require periodic exchange of used fluid
for new. Because of the "dirty" environments in which these types of equipment
are typically used, it is not uncommon for these fluids to not only become laden
with dirt particles, but other contamination and debris may also be carried in the
20 circulating fluid or may adhere to interior portions of the system. This
contamination of the fluid and the fluid's own degradation through use can have
detrimental effects on the systems within which they are contained. More
specifically, the operating fluids in both hydraulic and transmission systems serve
as lubricators, as well as operating fluids for each. The presence of the abrasive
25 particles and debris can result in damage to the various components that make up

the respective systems. If the particulate is large enough, it may also affect operation of the system.

In maintenance procedures, it is well known to drain these systems of the fluids contained therein. During this draining process, it is hoped that at least a
5 portion of the abrasive contaminants will be removed together with the spent fluids. Unfortunately, these abrasive particles oftentimes have greater densities than the operating fluids and therefore settle therefrom and are not drained together with the fluids. When these situations occur, solid sediment may become deposited within the hydraulic or transmission system and never be cleared
10 therefrom. As a result, increasing accumulations may form and ultimately cause damage to the system or compromise its utility for intended purposes and its useful life.

In view of these inadequacies associated with currently known methods for exchanging operating fluids of hydraulic and/or transmission systems, the present
15 invention has been developed to alleviate the same.

DISCLOSURE OF THE INVENTION: The present invention provides means through which a complete evacuation of both hydraulic and transmission systems on agricultural and heavy industrial equipment may be achieved. Not only are the
20 operating fluids evacuated from these systems, but the components of the systems are adequately flushed to remove substantial portions, if not all contaminating and abrasive matter that has accumulated therein. Three cleaning actions are made possible by the utilization of this invention. By using a rapid injection of cleaning fluid, sediment within the system is flushed therefrom

together with the cleaning solution. This action may be repeated thereby establishing a washing cycle so that remaining sediment becomes suspended within the cleaning fluid and adhering contaminants are more completely dislodged and swept from the system. On each cycle of the introduction and removal of
5 cleaning solution, the fluid is filtered to remove the contamination load caused by each cycle of inward and outward movement of the fluid. In a third action, cleaning fluid is circulated through the target system in a circuit-type fashion which may be optionally filtered and which causes a turbulent flow through the system that assures complete suspension of debris particles and dislodgment of adhering
10 contamination. After completing these several cleaning actions, fresh fluid may be reinjected into the system thereby replenishing the spent operating fluid with new fluid.

Not only do these actions remove dirt and other contamination from the fluid systems, but the forced reintroduction of fluid assures that replenishment of all
15 fluids throughout the system is thorough. This is important because it guarantees that there are not voids that may take the form of air pockets that can result in a "dry" start when the equipment is initially reactivated after the fluid exchange and flushing process. Still further, it is contemplated that these processes may be accomplished either manually by an operator or they may be automated and
20 executed by a computerized controller. In either case, the present invention has proved highly effective in accomplishing a reduction in required repair to agricultural and heavy industrial equipment, as well as extending the useful life of the same.

One embodiment of the present invention is a method for flushing a hydraulic system of a heavy equipment piece. A first step of the process is to open a drain port in a hydraulic system of the heavy equipment piece and drain used hydraulic fluid therefrom and into a waste reservoir that is maintained exterior to the equipment piece itself. A cleaning solution is then injected into the hydraulic system that purges remaining undrained hydraulic fluid from the system and into the waste reservoir. During this stage, the draining and purging fluids are monitored and it is detected when used hydraulic fluid ceases to flow from the system and when cleaning solution subsequently begins to flow from the hydraulic system. When this situation is detected, the drain port is closed and cleaning solution that continues to be injected is retained within the hydraulic system. The accumulated cleaning solution is ultimately evacuated from the hydraulic system and fresh replenishing hydraulic fluid is injected into the hydraulic system. The equipment piece may then be placed back into service with fresh fluids and usually improved performance.

Branch fluid flow paths may also be flushed using the present cleansing system by opening the control valves for a specific feature, such as a power brake, on a branch thereby opening the branch circuit to cleaning solution flow off of the primary flow path that otherwise bypasses that branch. By including the flushing of a plurality of branch paths off of the primary path, thorough cleaning of the hydraulic system and its components is assured.

BRIEF DESCRIPTION OF THE DRAWINGS:

Figure 1 is a schematic illustration of the flushing system according to the present invention showing the cooperation of the several components of the system and the fluid flows through the primary and branch fluid flow paths.

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MODE(S) FOR CARRYING OUT THE INVENTION:

Referring to Figure 1, the heavy equipment piece flushing system 05 is illustrated in schematic. Components of the flushing system, as well as of the hydraulic system 20 and/or transmission system 22 of an agricultural or heavy industrial equipment piece are illustrated. In the illustration of Figure 1, a hydraulic system 20 based on an agricultural tractor has been shown. It should be understood, however, that the flushing concepts and devices for achieving the same are considered to be interchangeable upon other agricultural pieces of equipment, as well as heavy industrial and construction equipment pieces.

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The hydraulic system 20 of the equipment piece includes a low pressure side 30 and a high pressure side 40. Each of the two sides are controlled by a main hydraulic pump 25 through which or around which the flushing action of the first cycle in the cleaning process occurs. Each of the two pressure sides 30,40 drain to an equipment piece hydraulic fluid reservoir or bathtub 45 that serves as a receptacle for hydraulic fluid during operation of the equipment piece and as a collector of cleaning solution in the flushing process. The bathtub 45 includes two reservoir drain ports 50 at lower extremities of the bathtub 45 and from which fluid connections are possible. A waste reservoir or drain fluid catch pan 55 is associated with the bathtub 45 and is typically positioned beneath the drain port(s)

50 so that fluid draining therefrom is caught and retained for disposal or reuse from the catch pan 55.

Prior to any flushing process being affected on an equipment piece, the used system fluid, in the illustrative case hydraulic fluid, is permitted to drain by gravity therefrom. In a first action of the flushing system, the several valves (V_x) are oriented so that operation of rotary pump 10a or 10b causes cleaning solution to be withdrawn from a cleaning solution heater and reservoir 60 and pumped through pressure hose 15 to the main hydraulic pump 25 of the tractor. As shown in Figure 1, a low pressure pump (P_L) 10a is located in parallel with a high pressure pump (P_H) 10b in the primary fluid flow path 90 of the flushing system 05. Either of the two pumps 10a,10b may be operator selected for use based upon the system 20,22 to be flushed.

In the case of a transmission system 22, relatively low pressures will be sufficient to inject cleaning solution throughout the system 22 to be flushed. On the other hand, if a hydraulic system 20 is to be flushed, significantly greater pressures will be required for injected cleaning solution to pass through various restrictions of the several flow paths 90,95 of the system 20 to be flushed. In the case of a hydraulic system 20 as typified in Figure 1, at the main hydraulic pump 25, the cleaning solution is first flushed through the low pressure side 30 of the hydraulic system 20 and secondly through the high pressure side 40 of the system 20.

The initial flushing of the low pressure side 30 is accomplished by the pressured cleaning solution being forced therethrough by the rotary pump 10b. In the illustrated example, a check valve CV_4 is located at the main hydraulic pump

25 that under sufficient pressure permits fluid to flow into and through the low pressure side of the system 20. During this flushing process, the high pressure rotary pump 10b is operated for a period of time typically lasting between two and three minutes. Based on the volumetric rate of fluid pumped therethrough, it is
5 typical for approximately three gallons of cleaning solution to be passed and flushed therethrough. At the commencement of the flushing process, one of the drain ports 50 is opened and as explained above, the hydraulic fluid from the system 20 is permitted to drain into a waste reservoir 55. When the high pressure pump 10b is initially actuated and cleaning solution injected into the system 20,
10 those remnants of hydraulic fluid that had remained in the system 20 are purged therefrom and out the drain port 50. This expression of the hydraulic fluid may be monitored or observed so as to detect when the hydraulic fluid ceases to flow from the system 20 and cleaning solution begins to flow. When this situation is detected, the drain port 50 is closed. Thereafter, the cleaning solution that is
15 continued to be injected into the system 20 flows into the hydraulic fluid reservoir 45 of the hydraulic system 20. After this initial injection of cleaning solution, the flow of solution is stopped and that cleaning solution accumulated in the reservoir 45 is evacuated or vacuumed therefrom using a diaphragm pump (P_v) 70. Because the cleaning solution is now burdened with contamination and other debris, it is
20 filtered through a first prefilter (F_1) 65 and then subsequently through a smaller porosity after-filter (F_2) 75 thereby eliminating that contamination and debris that may harm the system 20 if it were to remain.

The cleaning solution is vacuumed from the fluid reservoir 45 back into the original tank 60 from which it was withdrawn for reinjection and passage again

through the hydraulic system 20. At this stage, the tank 60 is considered an accumulation tank 60 where the filtered cleaning solution is reservoired for subsequent use. The accumulation tank 60 is the only tank actually contained within the portable flushing system 05 and in a preferred embodiment takes the form of a water heater or similar type device having a capability to raise and maintain the cleaning solution at approximately 110° Fahrenheit.

Utilization of the flushing system 05 upon a hydraulic system is as simple as making two connections; one upstream of the main hydraulic pump 25 of the system 20 in the primary fluid flow path 90 for injecting fluid and one connection at the drain port 50 which is typically at an extreme downstream location within the flow path 90.

It should be appreciated, that the present flushing system 05 can be used to flush equipment fluid systems such a transmission system 22 that does not offer significant resistance to the injection of cleaning solution. In these situations, the low pressure pump 10a will be utilized and develop sufficient pressure for the requisite cleaning operations. In hydraulic systems 20, however, significantly higher pressures, often exceeding 400 psi, will be required to affect the injection of cleaning solution throughout the entire system 20 and therefore the high pressure rotary pump 10b will be used.

After the original injection of cleaning solution and its subsequent evacuation from the hydraulic fluid reservoir 45 into the accumulation tank 60, one or more washing cycles may be affected wherein this process is substantially repeated so that further cleansing of the system 20 is made possible with rewarmed cleaning solution that is most effective at breaking down the

contamination to be removed from the system 20 and assuring that the contamination is suspended within the cleaning solution or dissolved therein. It is possible that this washing cycle will be sufficient to clean a given system 20,22. If that is the case, fresh replenishing fluid will be injected into the system 20,22 using whichever pump 10a,10b was used for the washing process. The replenishing fluid is withdrawn from a fresh fluid reservoir 57 and injected into the system 20,22 until all cleaning solution is expressed therefrom and all air pockets are removed. By utilizing this method of expressing the cleaning fluid and all air pockets with operating or hydraulic fluid, it is assured that a "dry" start will be avoided when the equipment piece is placed back into service. In this way, the present invention further avoids maintenance and extends the operational life of the equipment being flushed. If any drainage does occur from the hydraulic system 20, it is as designed by the manufacturer and not considered to be a detrimental effect. This condition may be likened to equipment standing idle and not running for a period of time between utilizations.

It is contemplated that the system to be flushed may be a transmission system 22 alone, a hydraulic system 20 alone, or a combination system wherein the transmission system used for moving the equipment piece about is a branch or portion of the overall hydraulic system 20 of the equipment piece.

In some situations, the intermittent washing process described hereinabove will not be sufficient for thoroughly cleaning the fluid passages of the target system 20. In those cases, a cleaning solution circulation circuit may be established using the injection pump 10 which has its intake, after an original filling of the system 20 with cleaning solution, off of the fluid reservoir 45 wherein

cleaning solution that has passed through the system 20 is collected. By having both the discharge and intake of the pump 10 placed at upstream and downstream positions, respectively, within the system 20 to be flushed, a continuous flow-circuit of cleaning solution may be established. When such a circulation is affected, the cleaning solution will be typically heated to a sufficient temperature that effective cleaning is accomplished. It is not expected, however, that the circuit will include passage through the heated accumulation tank 60. The circulation circuit will, however, include passage through both of the filters 65 and 75. In this manner, debris and contamination continue to be dislodged and scoured from the target system 20, and that removed debris will be filtered from the cleaning solution for more efficient cleaning as that solution continues to pass through passages of the system 20.

As may be appreciated in Figure 1, most hydraulic systems 20 have a primary fluid flow path 90 through which circulation continues at most times of operation keeping the various components supplied with lubricating fluid. There are also branch fluid flow paths 95 off of the primary path 90 typically utilized for driving accessories of the equipment piece. These driven accessories may range from hydraulic brakes, to hydraulic steering systems, and to apparatus for raising and lowering implements connected to the equipment piece such as plows and cultivators in the instance of agricultural equipment and road scrapers as examples of accessories to be raised and lowered on construction equipment pieces. In either case, one or more hydraulically driven accessory or feature (F_x) may be incorporated upon a single equipment piece. An example of three such features ($F_{1,2\text{and}3}$) are illustrated in Figure 1. Such a branch fluid flow path 95 is illustrated

with respect to one feature, F_1 . In a typical configuration, a feature such as the raising of an implement will be actuated by the opening of an inlet control valve (V_{F1}). This permits the passage of fluid past a check valve (CV_1) and ultimately through or to the feature (F_1). In the case of the raising of an implement, the feature would be a reciprocating piston and cylinder configuration. The pressure to overcome the check valve (CV_1) is less than that required to overcome the primary flow path check valve (CV_4). In this way, the branch fluid flow path 95 permits cleaning solution to pass therethrough as long as the control valve (V_{F1}) is opened. One or more features may be flushed by the establishment of successive branch flow paths 95. This cleansing of a plurality of features may be simultaneously accomplished, but more typically, the control valves (V_{FX}) will be operated sequentially and not simultaneously thereby causing each branch to be cleansed by circulating fluid passing therethrough, one at a time. Because the cleaning solution passing through the branch is expressed therefrom downstream to the primary flow path check valve (CV_4), fluid flow in the direction of the primary flow path 90 continues. The check valve (CV_4) prevents backward flow in the direction of the pump 10. Once the circulation is established, it may be continued indefinitely based upon the requirements of the system 20 and the desires of the operator.

In the illustration of Figure 1, a transmission system 22 is shown to be in-line with the circuit of the hydraulic system 20. This is an optional configuration, but one which permits a single cleaning operation of both the conventional components of the hydraulic system 20 and the hydraulically operated portions of the transmission system 22.

An optional configuration is accommodated based on the schematic of Figure 1. The main hydraulic pump 25 of some hydraulic systems 20 do not permit for the through passage of cleaning solution into the high pressure side 40 of the system 20. In those instances, a jumper conduit 35 may be required that connects into the hydraulic system 20 downstream from the equipment pieces pump (P_E) 25 and is controlled by a jumper valve (V_1). The valve (V_1) permits the redirection of cleaning solution off of the primary fluid flow path 90 and up into the high pressure side of the system 20 and then into one or more branch flow paths 95. A hydraulic return circuit has been illustrated wherein a transfer pump (P_T) is provided through which hydraulic fluid is returned back to the primary pump (P_E) for a sufficiently high pressure boost for utilization by the pressure driven features during regular operation of the hydraulic system 20.

In the illustration of Figure 1, multi-directional valves (V_X) are used to indicate the possible directions of flow therethrough. Valve (V_1) is utilized for permitting fluid flow passage through the flushing system 05 to the optional jumper 35, if required by the system 20 being flushed. Each feature (F_X) is controlled by an inlet control valve (V_{FX}) that operates in conjunction with check valves (CV_X) to assure uni-directional flow through the primary and branch fluid flow paths of the hydraulic system 20 being flushed. There are two drain ports 50, with each being controlled by one of valves (V_7) and (V_8). As indicated in Figure 1, valve (V_8) opens and closes drainage to the waste reservoir while valve (V_7) completes the circuit of the primary fluid flow path 90. This is accomplished through a return conduit 80 that causes the cleaning solution to pass through both filters 65 and 75. When the flow of cleaning solution reaches valve (V_5), it is

optionally directed toward the accumulation tank 60 when the evacuating diaphragm pump (P_v) is operational or valve (V_5) may direct the return fluid to either the low pressure pump 10a or the high pressure pump 10b, whichever is being utilized for a circulation cleaning. The selection between the pumps 10a and 10b is affected through the use of valves (V_2) and (V_3). The circulation of cleaning solution back to these pumps is also permitted or prevented by valve (V_4). This same valve (V_4), in conjunction with the valve (V_6) determines which fluid will be injected into the system 20 by the pumps 10a, or 10b. With the valve (V_6) in one position, cleaning solution is withdrawn from accumulation tank 60. In its other configuration, the valve (V_6) causes the withdrawal of replenishing fresh operating fluid from the reservoir 57 and injection into the hydraulic system 20.

The high pressure pump 10b is designed and selected so that it has capacity for delivering cleaning solution to the hydraulic system 20 at a pressure of at least 700 psi and a flow rate of at least 7 gallons per minute at that pressure. At this rate, turbulent flow will be achieved through the passages of the hydraulic system 20 so that a scouring effect is achieved on contamination adhering to interior walls of those passages and the flow will be sufficiently disturbed to maintain that contamination in suspension until removed therefrom by filters 65 and 75.

Through the unique flushing processes of the present invention, it has been discovered that repairs and scheduled maintenance may be reduced, while at the same time extending usable and operational life expectancies. Each of these factors prove beneficial to the equipment owners by reducing costs and minimizing down time experienced because of equipment required repairs or failures.

INDUSTRIAL APPLICABILITY: The present invention finds utility in all industries in which heavy equipment pieces are operated that have hydraulic or other fluid operating systems requiring periodic exchange and replenishment of operating fluids. Specific utility will be appreciated in the agricultural industries and the construction industries.

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WHAT IS CLAIMED IS:

1. A method for flushing a hydraulic system of a heavy equipment piece, said method comprising:

opening a drain port in a hydraulic system of a heavy equipment piece;
draining used hydraulic fluid from said hydraulic system into a waste reservoir exterior to said heavy equipment piece;

injecting a cleaning solution into said hydraulic system thereby purging remaining undrained hydraulic fluid from said hydraulic system into said waste reservoir;

monitoring the draining and purging fluids and detecting when used hydraulic fluid ceases to flow from said hydraulic system and cleaning solution begins to flow from said hydraulic system;

closing said drain port and retaining injected cleaning solution within said hydraulic system;

evacuating accumulated cleaning solution from said hydraulic system; and
replenishing said hydraulic system with fresh hydraulic fluid.

2. The method as recited in claim 1; said method further comprising:

said hydraulic system being a transmission system of said heavy equipment piece, said transmission system being useable to move said equipment piece between locations.

3. The method as recited in claim 1; said method further comprising:
flushing a transmission system of said heavy equipment piece while also flushing said hydraulic system, said transmission system being placeable in fluid communication with said hydraulic system.
4. The method as recited in claim 1; said method further comprising:
discontinuing the injection of cleaning solution into said hydraulic system prior to the step of evacuating accumulated cleaning solution from said hydraulic system.
5. The method as recited in claim 1; said method further comprising:
performing at least one washing cycle after an initial evacuation of accumulated cleaning solution from said hydraulic system, said washing cycle comprising:
injecting cleaning solution into said hydraulic system; and
evacuating accumulated cleaning solution from said hydraulic system.
6. The method as recited in claim 1; said method further comprising:
collecting evacuated cleaning solution in an accumulation tank, said accumulation tank being capable of heating cleaning solution contained therein.

7. The method as recited in claim 6; said method further comprising:
- performing at least one washing cycle after an initial evacuation of accumulated cleaning solution into said accumulation tank from said hydraulic system, said washing cycle comprising:
- injecting cleaning solution into said hydraulic system from said accumulation tank; and
- evacuating accumulated cleaning solution from said hydraulic system back into said accumulation tank.
8. The method as recited in claim 6; said method further comprising:
- filtering evacuated cleaning solution to remove particulate prior to said cleaning solution's collection in said accumulation tank.
9. The method as recited in claim 1; said method further comprising:
- establishing a continuous flow cleaning fluid circulation within said hydraulic system, said circulation establishment comprising:
- injecting cleaning solution into said hydraulic system using a circulation pump;
- passing said injected cleaning solution through said hydraulic system;
- vacuuming said passed cleaning solution from said hydraulic system using said circulation pump; and
- reinjecting said cleaning solution into said hydraulic system using said circulation pump and thereby establishing said continuous flow cleaning fluid circulation within said hydraulic system.

10. The method as recited in claim 9; said method further comprising:
filtering said vacuumed cleaning solution to remove particulate therefrom prior to reinjection into the hydraulic system.
11. The method as recited in claim 9; said method further comprising:
flushing at least one branch fluid flow path of said hydraulic system, said branch path extending from a primary fluid flow path of said hydraulic system and being utilizable for driving an operable feature of said heavy equipment piece;
said branch flushing step comprising:
opening an inlet control valve between said primary flow path and said branch flow path thereby causing at least a portion of the circulating cleaning fluid to divert from said primary flow path and pass through said branch flow path; and
returning said cleaning fluid to said primary flow path from said branch path for continued circulation in said hydraulic system.
12. The method as recited in claim 11; said method further comprising:
said inlet control valve to said branch flow path being an actuatable valve useable during the heavy equipment piece's operation to activate an associated hydraulically driven feature of said heavy equipment piece such as the raising and lowering of an attached implement.

13. The method as recited in claim 12; said method further comprising:
closing said inlet control valve to said branch flow path thereby stopping cleaning solution flow through said branch flow path.
14. The method as recited in claim 13; said method further comprising:
subsequently flushing at least one additional branch fluid flow path of said hydraulic system, wherein said flushing step of each branch comprises:
opening an inlet control valve between said primary flow path and said branch flow path thereby causing at least a portion of the circulating cleaning fluid to divert from said primary flow path and pass through said branch flow path; and
returning said cleaning fluid to said primary flow path from said branch path for continued circulation in said hydraulic system.
15. The method as recited in claim 1; said method further comprising:
injecting cleaning solution into a primary fluid flow path of said hydraulic system at sufficiently high pressure to overcome and pass by a check valve positioned across said primary fluid flow path, said check valve included within said hydraulic system for preventing backward flow of hydraulic fluid during said hydraulic system's operation.

16. The method as recited in claim 15; said method further comprising:
said sufficiently high pressure for injection of cleaning fluid into said primary fluid flow path of said hydraulic system being at least 300 psi.
17. The method as recited in claim 11; said method further comprising:
injecting cleaning solution into a primary fluid flow path of said hydraulic system at sufficiently high pressure to overcome and pass by a check valve positioned across said primary fluid flow path, said check valve included within said hydraulic system for preventing backward flow of hydraulic fluid during said hydraulic system's operation.
18. The method as recited in claim 11; said method further comprising:
said sufficiently high pressure for injection of cleaning fluid into said primary fluid flow path of said hydraulic system being at least 300 psi.
19. The method as recited in claim 18; said method further comprising:
said circulation pump being a rotary pump capable of delivering fluid pressures in excess of 300 psi.

20. The method as recited in claim 18; said method further comprising:

said circulation pump being a rotary pump, said rotary pump delivering fluid pressures to said hydraulic system in excess of 700 psi and at a flow rate of 7 gallons per minute thereby creating a turbulent flow within said hydraulic system; and

scouring debris adhering to interior surfaces of said hydraulic system therefrom with said turbulent flow.

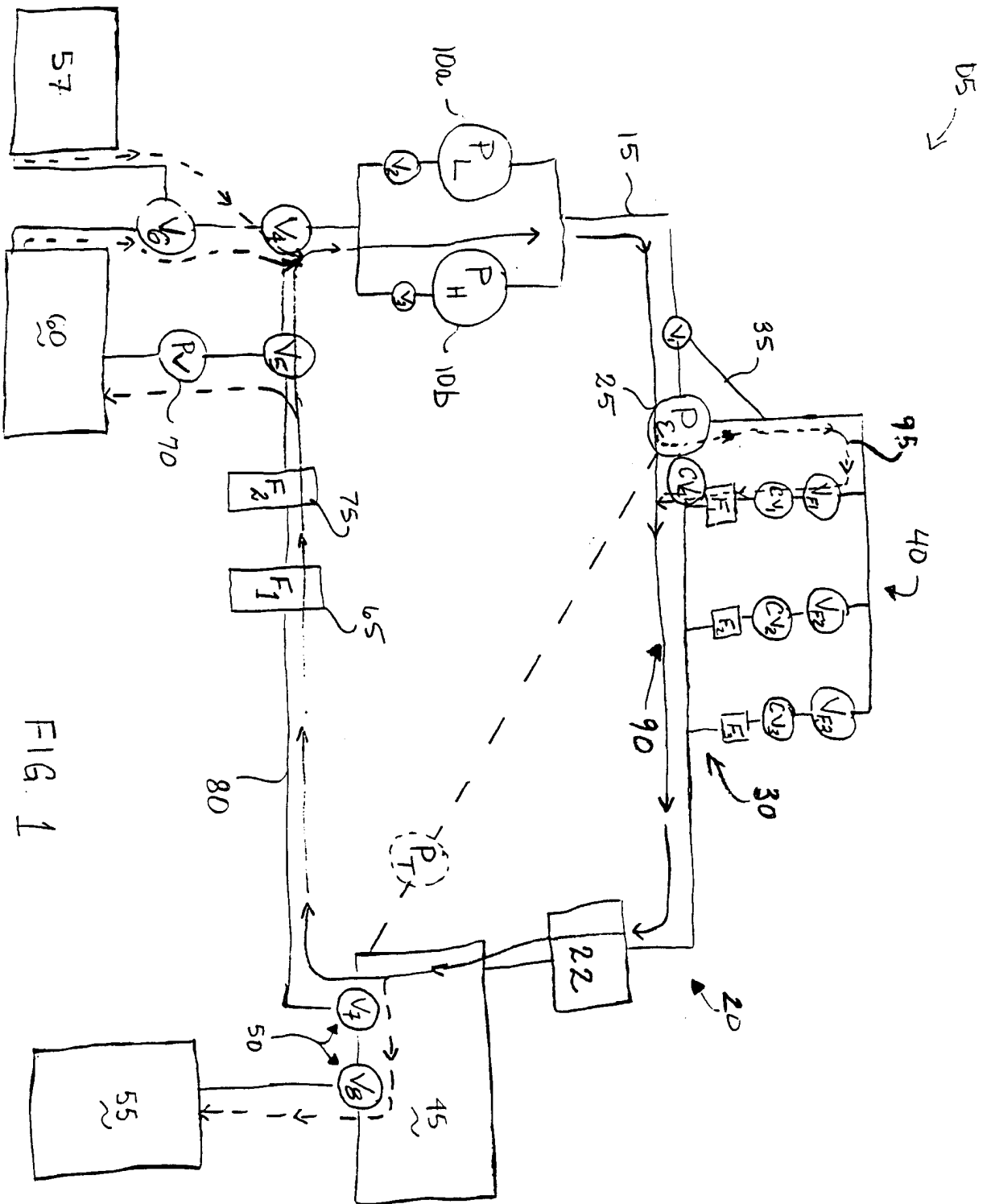


FIG. 1