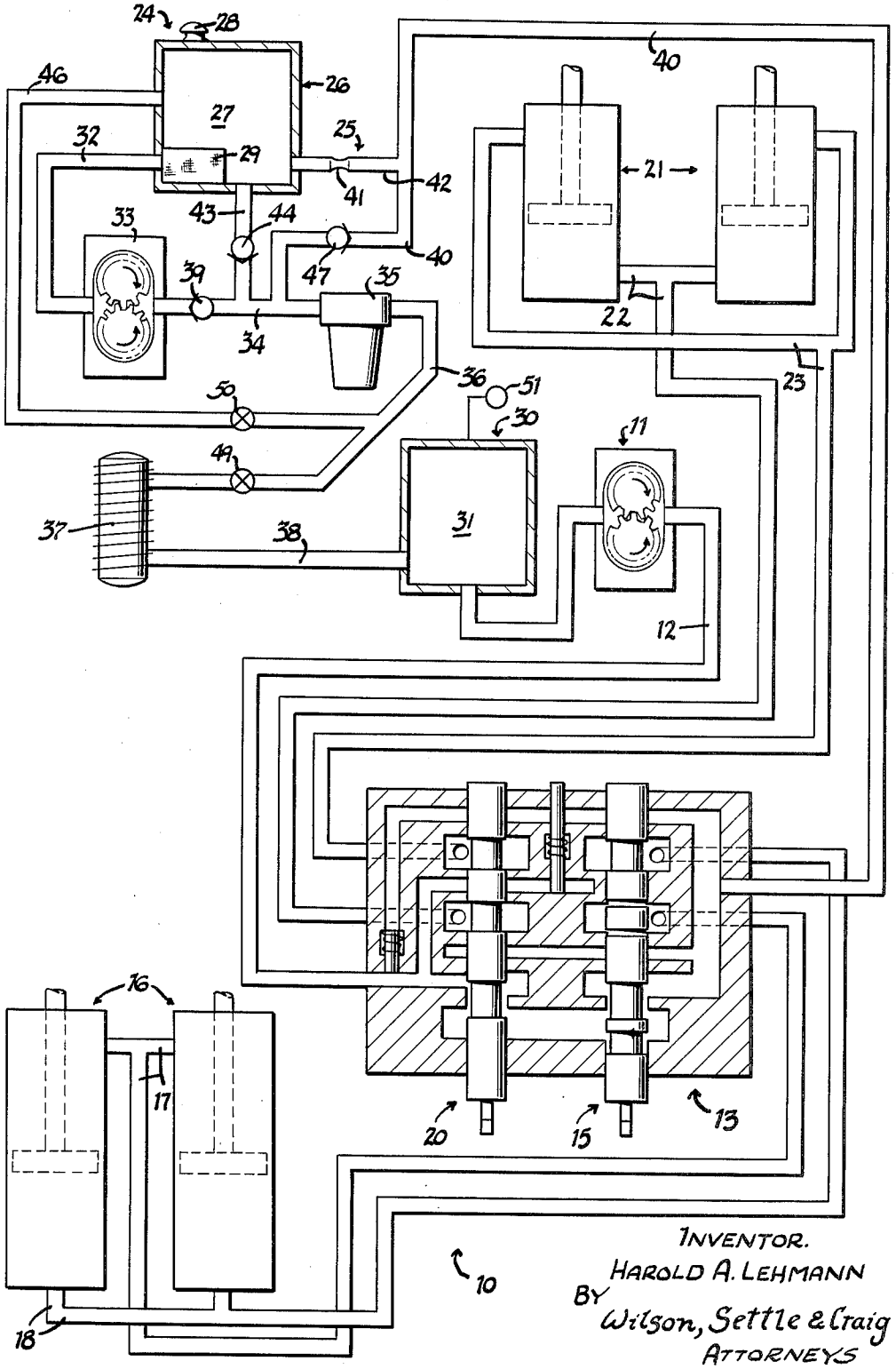
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HYDRAULIC APPARATUS AND METHOD

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INVENTOR.
HAROLD A. LEHMANN
BY
Wilson, Settle & Craig
ATTORNEYS

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HYDRAULIC APPARATUS AND METHOD

Harold A. Lehmann, Racine, Wis., assignor to J. I. Case Company, Racine, Wis., a Wisconsin corporation

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The present invention relates to a hydraulic apparatus and method, and more particularly to a novel compound circuit hydraulic system having incorporated therein a recirculation line for continuously supplying to a system pump within a main circuit contaminant-free, pre-cooled, hydraulic fluid at superatmospheric pressures substantially less than the output pressure of the system pump, the system including an auxiliary circuit accommodating compensating fluid flow exclusively to and from the main circuit as volume demand for work producing fluid varies in the main circuit.

In the operation of hydraulically actuated prime movers or the like field equipment, contamination of the hydraulic fluid proposes a serious and ever-present problem. Such systems are conventionally provided with hydraulic fluid from a reservoir which is open to the atmosphere and in which the level of fluid fluctuates as the requirement for hydraulic fluid in the system varies. As the fluid level in such a reservoir drops, atmospheric air enters the reservoir to avoid the formation of a vacuum or the like in the hydraulic system which would lead to pump or like system equipment damage. Since such machines normally operate in the field where dust and airborne solids are necessarily present, solid contaminants readily become intermixed with the oil in the reservoir, and the entire system shortly becomes contaminated. Various attempts to provide air cleaners or filters to avoid such contamination in the reservoir have been unsuccessful, since such cleaners or filters readily become clogged and must be continuously and conscientiously maintained in order to be effective.

The present invention provides a novel solution to this problem of hydraulic fluid contamination and positively avoids fluid starvation by providing a simple and inexpensive method and apparatus which continually equates the fluid supplied to with the fluid discharged from a pressurized system reservoir within a main circuit of the system as fluid volume demand varies during operation of the system. Used work fluid is continuously returned to the system reservoir for subsequently supplying cleaned, cooled, contaminant-free hydraulic fluid to a system pump which pressurizes the fluid for subsequent fluid work. When returned fluid exceeds system demand, the excess is automatically bled off into an atmospheric reservoir within an auxiliary circuit of the system. The atmospheric reservoir also automatically supplies make-up fluid to the main circuit when the return fluid is less than system demand.

The present invention utilizes a compound circuit hydraulic system with the atmospheric reservoir situated in the auxiliary circuit and adapted to intermittently supply fluid to or receive fluid from the main circuit as the fluid volume requirements in the main circuit varies due to changing working conditions. The second, pressure reservoir, situated in the main circuit, is continuously supplied with a flow of fluid which accurately balances the varying fluid discharge from that reservoir. This supplied flow of fluid is, for the most part, composed of return fluid which is recirculated within the main circuit following use for additional use, with excess return fluid which occurs intermittently being drained into the atmospheric reservoir in the auxiliary circuit. When the volume of fluid discharged from the second reservoir exceeds the return fluid being recirculated, a flow of make-up fluid in the amount of the deficiency occurs

between the atmospheric reservoir in the auxiliary circuit and the second pressure reservoir in the main circuit. All fluid influent into the second reservoir is pre-filtered and pre-cooled. To carry out the foregoing functions, a return line interconnects a fluid motor or the like within the main circuit for accommodating the above-described recirculation of used fluid. A fluid supply line, with a supply pump disposed therein, interconnects the atmospheric reservoir and the return line which accommodates the previously mentioned intermittent flow of make-up fluid. A filter and heat exchanger are serially interposed in the return line between the juncture with the supply line and the second reservoir. In this manner, all fluid supplied to the second reservoir, whether by recirculation or by make-up flow from the first reservoir, is pressurized, filtered and cooled, prior to use in the main circuit. Futhermore, a pressure relief fluid by-pass line, with a fluid flow control device disposed therein, such as a check valve or a pressure operated orifice, is provided to exhaust any excess return fluid within the main circuit and also to recirculate to the first reservoir any excess fluid supplied by the supply pump.

Thus, it is not necessary to maintain the fluid in the atmospheric filter nor in the return line under sanitary conditions, yet fluid in the sealed reservoir is always clean. All oil delivered to the sealed reservoir, whether recirculated or supplied from the atmospheric reservoir, is pressurized, pre-filtered and pre-cooled. There is no necessity for any elaborate and costly air cleaning mechanisms which normally require maintenance, filter element replacement and the like. A volume of fluid under pressure in excess of any work requirement is always made available at the sealed reservoir by reason of the recirculated fluid influent which is supplemented from time to time by the make-up fluid from the atmospheric reservoir. In this way, any danger of system pump cavitation or the like is positively eliminated, and a full and adequate supply of clean cool fluid under pressure is assured. By recirculating fluid in the main circuit, only make-up fluid is required from the supply pump. At the same time, overloading of the main or working circuit is avoided by returning the previously utilized hydraulic fluid in excess of main circuit work requirements to the atmospheric reservoir located in the atmospheric reservoir located in the auxiliary circuit.

It is, therefore, an important object of the present invention to provide a new and improved method of and apparatus for supplying hydraulic fluid to a hydraulic system.

Another important object of this invention is the provision of means for continuously supplying quantities of pressurized, pre-filtered, pre-cooled hydraulic fluid commensurate with varying work needs to the pump of a hydraulic system.

Yet another object is the provision of a novel reservoir arrangement for a compound circuit hydraulic system including a working or main circuit and an auxiliary supply circuit, each supplied with a reservoir, the reservoir of the working circuit having an influent line continuously fed by return fluid in the working circuit and intermittently supplemented by make-up fluid pumped by a supply pump through a supply line interconnecting the auxiliary reservoir with the influent line, so that both the return fluid and the make-up fluid necessarily pass through a cleaning filter and a cooling heat exchanger, serially disposed in the return line upstream of the working circuit reservoir, prior to entry into that reservoir.

Another, and no less important, object of this invention is the provision of a novel method of supplying influent hydraulic fluid to a recirculatory main hydraulic circuit by providing an atmospheric fluid reservoir of fluctuating level, removing fluid from the atmospheric reservoir when-

ever the demand in the recirculatory system exceeds the volume of fluid being recirculated therein, and pre-filtering and pre-cooling all main circuit influent fluid under pressure prior to use.

Other objects and features of this invention will appear in the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification in which:

The single figure of drawings is a schematic representation of a hydraulic system of conventional type provided with a presently preferred embodiment of the dual reservoir, multiple network hydraulic system of the present invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

As shown on the drawings:

Reference numeral **10** indicates generally a hydraulic system of the type conventionally utilized in off-the-road utility mechanisms, such as loaders and the like. For example, the system is particularly utilizable with a loader such as that sold by the J. I. Case Company of Racine, Wisconsin, under the designations "W–9 Terraload'r."

As is typical in such installations, the system includes a gear-type system pump, indicated generally at **11**, delivering pressurized fluid through a conduit **12** to a dual-spool control valve, indicated generally at **13**. The right-hand spool **15** of the valve **13** can be actuated to deliver fluid under pressure to bucket lift cylinders **16** through conduits **17** and **18**. The lefthand spool **20**, when actuated, delivers fluid under pressure to bucket tilt cylinders **21** through conduits **22** and **23**.

This much of the system is conventional, and it is unnecessary to describe the system in greater detail.

The pump **11** is supplied with hydraulic fluid through a main hydraulic circuit of the system of the present invention, indicated generally at **25**.

This main hydraulic circuit is augmented by an auxiliary circuit **24** in which is situated an atmospheric reservoir tank **26** enclosing an interior space **27**, vented to the atmosphere by conventional means, as by a breather cap **28**. Disposed interiorly of the reservoir space **27** is a filter screen **29**. A second, sealed, pressurized reservoir **30** is provided in the main circuit **25** in spaced relation to the reservoir tank **26**. This second tank **30** is completely enclosed and is fluid-tight to provide a sealed interior reservoir chamber **31**. Of course, a manually actuated air bleed valve (not shown) should be provided for start-up. The reservoir chambers **31** and **27** are interconnected by a conduit, indicated generally at **32**, and having disposed therein a gear-type hydraulic fluid pump of conventional design, indicated generally at **33**.

This pump **33** has its intake side connected through the conduit **32** to the reservoir chamber **27**, and has its pressure output side connected by the portion **34** of the conduit **32** through a check valve **39**, which prevents reverse flow from the main circuit **25**, to the auxiliary circuit **24** through a filter **35**, also of conventional design. The filter **35**, in turn, is connected through a conduit portion **36** to the inlet side of a conventional finned heat exchanger **37**. The outlet side of the heat exchanger **37** is connected through conduit portion **38** to the enclosed reservoir space **31**.

It is also to be noted that the valve body **13** is connected with portion **34** of conduit **32** by means of a return line **40**. Used hydraulic fluid, i.e., return fluid from the cylinders **16**, **21** or fluid merely by-passed through the valve body **13** from the constant displacement pump **11**, is redelivered through line **40** and check valve **47** contained therein to conduit portion **34** for filtering, cooling and reuse following return to reservoir chamber **30**. Check valve **47** is set to easily accommodate return flow while prohibiting flow in the reverse direction from conduit portion **34** into return line **40** responsive, for example, to pressure created by supply pump **33**.

During the operation of the apparatus utilizing the hydraulic system **10**, the volume of hydraulic fluid required by in the cylinders **16** and **21** will vary substantially, thereby causing fluctuation in the demand for hydraulic fluid. Consequently, the fluid recirculated through line **40** will intermittently either exceed or will be less than the work demand. This is principally due to the piston rod volume difference between the fluid required to advance, as opposed to the fluid required to retract, the cylinders **16** and **21**.

When the fluid supply from line **40** exceeds the demand, the excess is discharged through a pressure-operated orifice **41**, disposed in conduit **42** which in turn is interposed between return line **40** and atmospheric reservoir **26**. When the fluid supply from return line **40** is less than the demand, the deficiency is supplied from atmospheric reservoir **26** through conduit **32**, supply pump **33** and check valve **39**.

Thus, the exact quantity of hydraulic fluid flow commensurate with the varying work demands is supplied to reservoir chamber **31** in a pressurized, filtered, cooled condition. Used fluid is continuously recirculated through return line **40** and check valve **47** and, when of less volume than required by main valve body **13**, is joined by make-up fluid emanating from reservoir chamber **27** and flowing through conduit **32**, pump **33** and check valve **39** under the impetus of supply pump **33**. Thereafter, the combined flow, if it so be combined, is displaced through filter **35** and heat exchanger **37** for cleaning and cooling, respectively, prior to being discharged into pressurized reservoir chamber **31**. When return fluid traversing line **40** exceeds the demand of main valve body **13**, the excess is automatically bled off through orifice **41** and conduit **42** into reservoir chamber **27**. By reason of the foregoing system, pump **11**, which inherently must be an expensive pump, is effectively guarded against fluid starvation damage, as, for example, that caused by cavitation or by an inadequate supply of fluid flow. Pump **33**, which makes up any deficiency in the required fluid volume, may be a relatively inexpensive low discharge pump, thereby adding to the cost advantage of this efficient, contaminant-free hydraulic system.

In the event that the pump **33** fails or malfunctions during operation, a pressure gauge **51**, situated to sense the pressure in the reservoir **31**, will alert the operator to shut down the system before damage is caused to the expensive pump **11**, due to running dry and the like.

Alternatively, the orifice **41** may be of the commercially available so-called one-way type, accommodating full flow out of reservoir **27** into reservoir **31** through conduits **36**, **38** and **40** upon failure of the pump **33**, but restricting flow into reservoir **27** during normal operation.

Conduit **43**, which interconnects portion **34** of conduit **32** and reservoir space **27** and has a pressure relief valve **44** disposed therein, is provide (1) to recirculate to the reservoir **27** the output of pump **33** when make-up fluid is not required in the working circuit and (2) to prevent excess pressures in the working circuit when there is an excess amount of fluid therein. Thus, the pressure relief valve **44** sets the pressure attained and maintained in the reservoir space **31**, this pressure preferably being on the order of 25 pounds per square inch, as a maximum.

A further conduit, designated **46**, provides a by-pass fluid return from the conduit portion **36**, intermediate filter **35** and heat exchanger **37**, to the atmospheric reservoir chamber **27** to accommodate additional filtering action by recirculation of the filter effluent fluid one or more additional times through filter **35**. This feature is especially valuable when the filter element within filter

35 is removed and replaced resulting in advertent, unavoidable dislodging of contaminating particles from the old filter into the fluid of conduit portion 36. Procedurally, a manual valve 49 within conduit portion 36 adjacent the entrance to heat exchanger 37 is closed, a manual valve 50 situated in by-pass line 46 is opened, accommodating recirculation of the filter effluent fluid through conduit 46, reservoir chamber 27, conduit 32, and filter 35, for a time sufficient to purge the contaminating particles from the fluid at which time normal circulation from filter 35 through heat exchanger 37 into sealed reservoir chamber 31 is resumed. Of course, system pump 11 is not operated during the above-described intervals.

The operation of the system heretofore described will be readily appreciated by those skilled in the art. The presence in the reservoir chamber 31 of fluid at a pressure sufficient to maintain the reservoir filled at all times, the continuously recirculated return flow of used fluid through conduit 40 supplemented by flow from reservoir chamber 27 as necessary, the provision of filtered, contaminant-free liquid in the reservoir space 31, and the presence of cooled hydraulic fluid in the space 31 insures a continuous, accurate, noncavitating supply of hydraulic fluid to the constant displacement gear-type supply pump 11. The pressure venting of excess return fluid through conduit 42 and orifice 41 into the atmospheric reservoir 27 confines to the atmospheric reservoir 27 any excess fluctuations in fluid requirement. The system insures the cooling of all fluid delivered to reservoir 30 in the heat exchanger 37 prior to its reintroduction into the system through the system pump 11. The utilization of the pressure relief valve 44 and the line 43 easily and simply regulates the pressure in the reservoir space 31. Since there is no substantial fluctuation in level in the space 31, there is no tendency to "breathe in" any contaminants.

I claim:

1. In a hydraulic system wherein a system pump supplies hydraulic fluid under realtively high pressure to a motor element under the control of a valve element, a novel dual reservoir system for supplying a volume of clean, cool hydraulic fluid commensurate with varying motor element demands to said system pump at superatmospheric pressures substantially less than the output pressure of said system pump comprising first and second reservoirs separate and distinct from one aonther, said first reservoir being vented to the atmosphere and said second reservoir being sealed from the atmosphere and supplying fluid directly to said system pump, a valve conduit interconnecting said reservoirs, a supply pump interposed in said interconnecting conduit and intermittently supplying make-up fluid to said system reservoir at superatmospheric pressure less than the pressure supplied by said system pump, recirculating means discharging used fluid into said interconnecting conduit mergeable with the intermittent flow of make-up fluid, a filter and a heat exchanger interposed in said interconnecting conduit between said supply pump and said second reservoir downstream of said recirculaitng discharge for cleaning and cooling all fluid flow prior to delivery into the second reservoir.

2. In a method of supplying hydraulic liquid to a system pump of a hydraulic system, the steps of

(1) recirculating liquid following system use for system resuse,

(2) intermittently removing liquid from an atmospheric reservoir space to supplement said recirculated liquid as necessary thereby avoiding damage to system equipment,

(3) providing a single liquid stream of flow by merging the liquid of steps (1) and (2) when simultaneous flow occurs,

(4) filtering said liquid stream and

(5) cooling said liquid stream,

(6) confining the filtered and cleaned liquid stream as a pressurized liquid body in a second reservoir space,

(7) supplying liquid under pressure from said second reservoir space to said system pump.

3. In a hydraulic system having a system pump, a valve element and a hydraulically powered motor element receiving hydraulic fluid under pressure from said pump and under the control of said valve, the improvements of a sealed system reservoir for supplying fluid under pressure to said system pump, an auxiliary atmospheric reservoir for supplementing a recirculated supply of fluid, a supply pump, a first conduit connecting the intake of said supply pump with said atmospheric reservoir, a second conduit connecting both the pressure side of said supply pump and a system recirculating conduit with said system reservoir, a filter and a heat exchanger serially interposed in said second conduit, and pressure-operated flow accommodating means accommodating intermittent unidirectional flow of fluid in excess of need from system recirculating conduit to the atmospheric reservoir.

4. In a method of supplying hydraulic liquid to the system pump of a hydraulic system, the steps of

(1) recirculating liquid following use for reuse,

(2) intermittently removing liquid from a reservoir space maintained at atmospheric pressure,

(3) providing a single stream of flow by merging the liquid of steps (1) and (2) when simultaneous flow occurs,

(4) filtering said liquid stream and

(5) delivering said liquid to the atmospheric reservoir space,

(6) thereafter refiltering said liquid to insure a fully purged filtrate,

(7) cooling said refiltered liquid,

(8) confining the refiltered liquid as a pressurized liquid body in a second reservoir space,

(9) supplying liquid under pressure from said second reservoir space for use in said system pump.

5. In a hydraulic system wherein a system pump supplies hydraulic fluid under relatively high pressure to a motor element under the control of a valve element, a novel component circuit reservoir system for supplying said system pump with a sufficient volume of clean, cool hydraulic fluid at superatmospheric pressures substantially less than the output pressure of said system pump while avoiding damage to the system pump by reason of avoiding fluid starvation comprising first and second reservoirs separate and distinct from one another, in a main circuit and an auxiliary circuit, respectively, said first reservoir (1) containing fluid at atmospheric pressure (2) intermittently receiving return fluid from said valve element and, (3) intermittently supplying supplementing fluid to the second reservoir, said second reservoir being sealed from the atmosphere and supplying fluid directly to said system pump, a first conduit serially interconnecting said reservoirs, and a supply pump, a filter, and a heat exchanger interposed in said first conduit, a recirculation conduit interposed between said motor element and said first conduit adjacent the outlet pressure side of the supply pump, and pressure vent means disposed in fluid pressure communicating relation between said first conduit downstream of the supply pump to vent excess pressure and thereby control the pressure at which the second reservoir is to be maintained.

6. In a method of supplying hydraulic liquid to the system pump of a hydraulic system, the steps of

(1) recirculating liquid following system use for system reuse,

(2) intermittently removing liquid from an atmospheric reservoir space to supplement said recirculated liquid as necessary thereby avoiding damage to system equipment,

(3 providing a single liquid stream of flow by merging the liquids of steps (1) and (2) when simultaneous flow occurs,
(4) filtering said liquid stream and
(5) cooling said liquid stream,
(6) conducting the filtered and cleaned liquid stream as a pressurized liquid body to a second reservoir space,
(7) supplying liquid under pressure from said second reservoir space to said system pump, and
(8) intermittently returning fluid from said system following use to the first reservoir when demand exceeds need for subsequent reintroduction into said second reservoir by the performance of step (6) only after said steps (2) through (5) have been performed thereon.

7. In a hydraulic system having a system pump, a valve element and a hydraulically powered motor element receiving hydraulic fluid under pressure from said

pump and under the control of said valve, the improvements of a sealed system reservoir for supplying fluid under pressure to said system pump, an atmospheric reservoir for supplementing a recirculated supply of fluid, a supply pump, a first conduit connecting the intake of said supply pump with said atmospheric reservoir, a second conduit connecting both the pressure side of said supply pump and a system recirculating conduit with said system reservoir, a filter and a heat exchanger serially interposed in said second conduit, and a return by-pass conduit interconnecting said second conduit and the atmospheric reservoir to accommodate selective recirculation of potentially contaminated fluid within the first and second conduits through the filter to insure delivery of a fully purged filtrate to the system reservoir.

No references cited.

EDGAR W. GEOGHEGAN, *Primary Examiner.*