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MEANS AND METHOD FOR SEPARATING GASES FROM LIQUIDS

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4 Sheets-Sheet 1

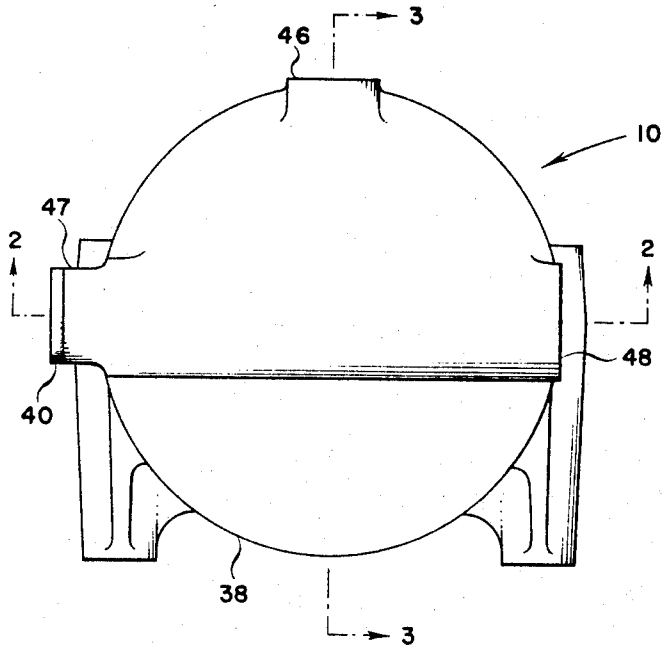


FIG. 1

FIG. 4

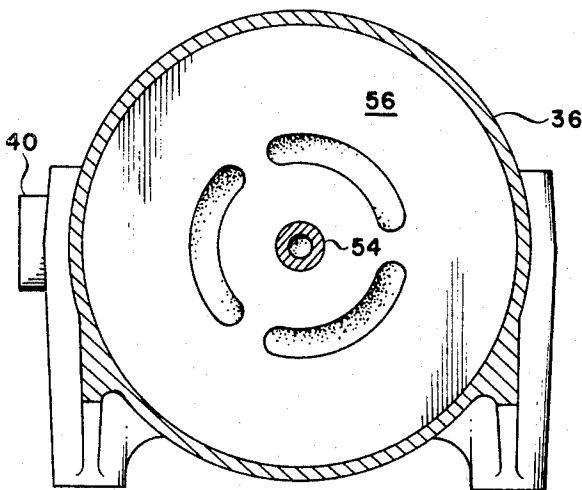
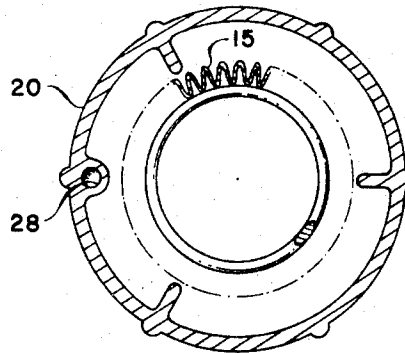


FIG. 5

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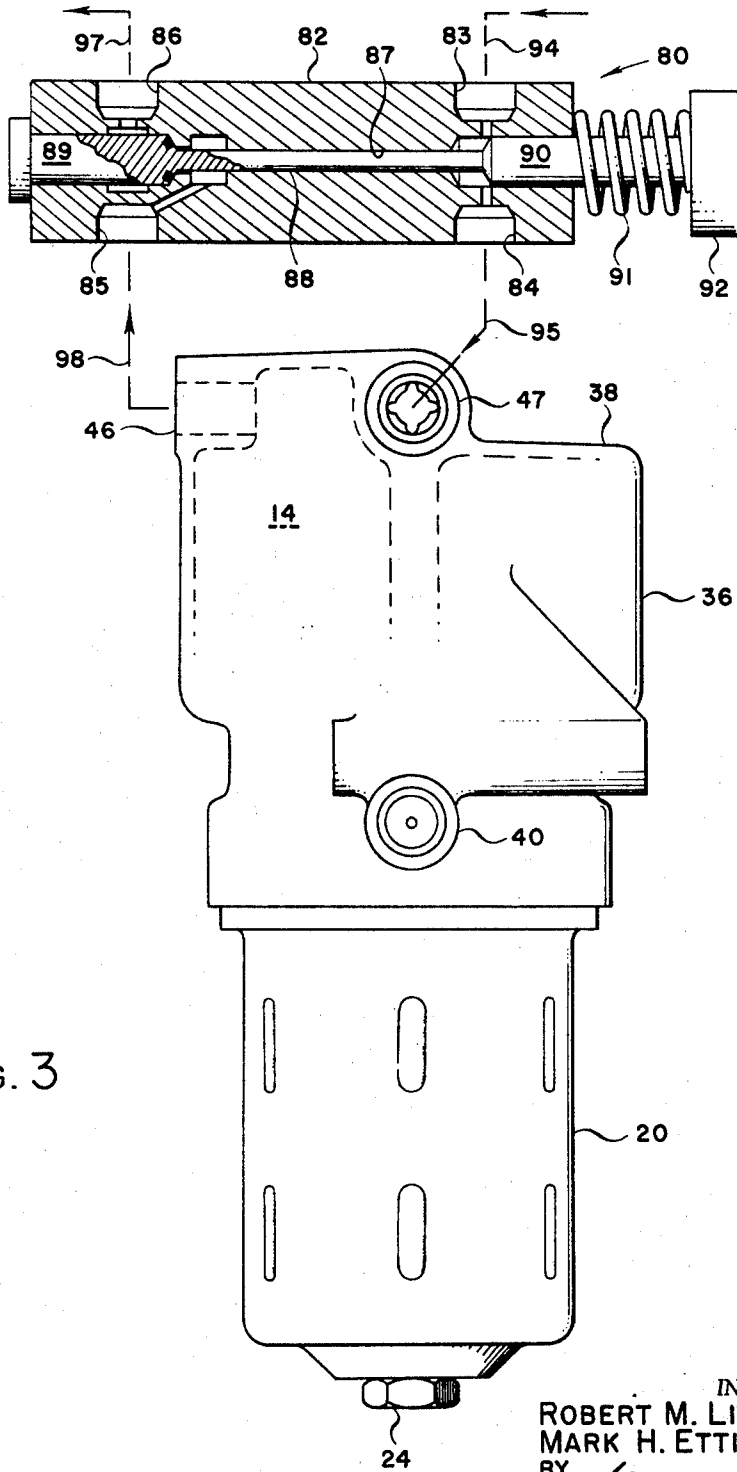
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

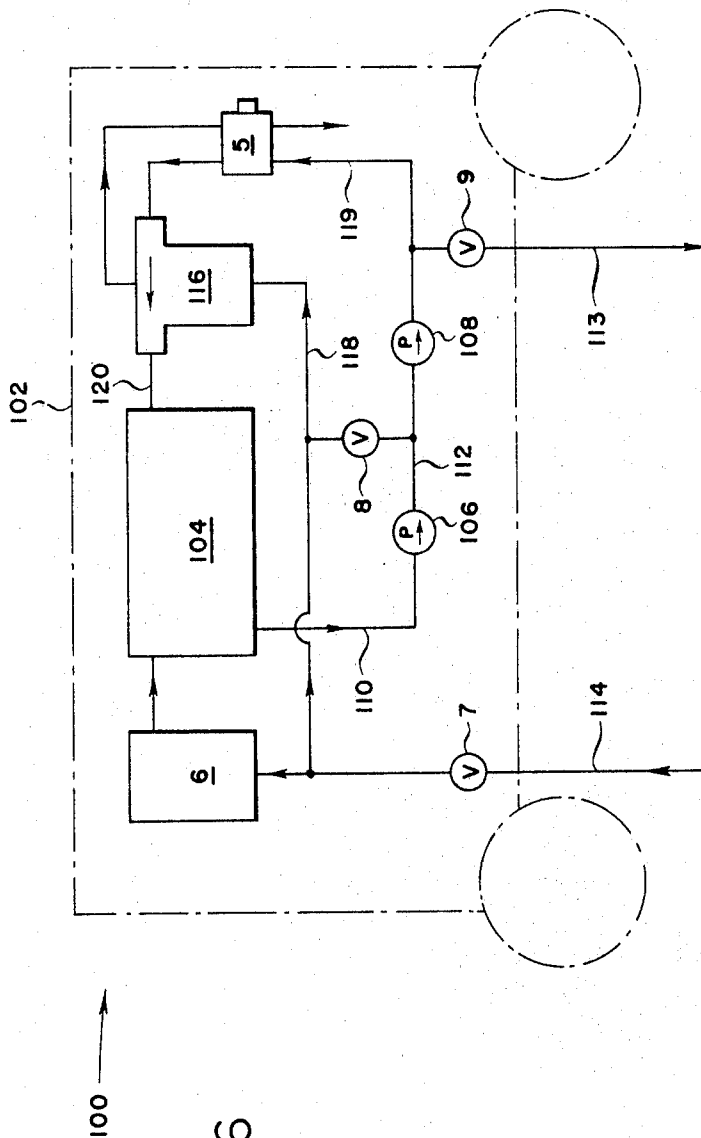


FIG. 6

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MEANS AND METHOD FOR SEPARATING GASES FROM LIQUIDS

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9 Claims. (Cl. 55—46)

This invention relates to means and method for separating gases from liquids and more particularly to such apparatus which is capable of reducing the gas content of a liquid in a pressurized system to a predetermined subatmosphere level while maintaining complete integrity of the system by virtue of being energized solely by the liquid of the system.

Although the device of the present invention has a number of different applications, such as removing air from oil in a hydraulic servo system, deaerating boiler feed water, etc., it is particularly useful for removing entrained and dissolved air from the hydraulic fluid in a pressurized, hydraulic system of an airplane wherein the system cannot be vented to atmosphere. While the device is adaptable for the removal of various gases, it is usually referred to with regard to air removal.

The hydraulic fluid employed to actuate various devices on an airplane will not operate satisfactorily if it has excessive amounts of air entrained in it. In the usual case, the operating pressure of the fluid is approximately 3,000 p.s.i.g. and the pressure in the line returning the fluid from devices which have been operated by it is approximately 40 p.s.i.g. The operation of the hydraulic system on an airplane is tested on the ground by means of a ground service cart. Such a cart comprises, essentially, a reservoir of hydraulic fluid which is conventionally pressurized with air to approximately 30 p.s.i.g. to furnish sufficient head to operate a high pressure pump supplying fluid to the aircraft under 3,000 p.s.i.g. Since hydraulic fluid absorbs air, testing the hydraulic system in this manner introduces entrained air.

With a ground service cart including the present invention, on the other hand, it is possible to employ a reservoir which is maintained under a vacuum so that air will not become entrained within the fluid. With this arrangement, sufficient head for the high pressure pump is supplied by employing a low pressure pump to accept gravity flow from the reservoir and provide a continuous supply of fluid under pressure to the high pressure pump.

The general concept of deaerating liquids by subjecting the liquid to subatmospheric pressure and simultaneously flowing the liquid through a filter barrier is known. However, in the usual device of this type, the subatmospheric pressure is employed only to create a pressure differential in order to force the liquid and entrained air through the filter. The filter frees the air from the liquid as it passes through and the free air is carried along with the liquid to the original storage tank of unfiltered liquid where the air is allowed to escape to the atmosphere. Such devices employ a filter barrier for the purpose of creating flow disturbance or turbulence, causing minute bubbles of entrained gases to coalesce or to break the fluid into small droplets to provide a large surface-to-volume ratio for enhancing the effect of the vacuum degassifying the fluid. Although generally satisfactory, these device have the drawback that they cannot be used in a system which must remain pressurized throughout and which cannot be vented to atmosphere. Such systems are found on airplanes which are subjected to acrobatics because, when an airplane is flying in an inverted position, reservoirs for the hydraulic

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system cannot be vented to atmosphere. Airplanes wherein hydraulic pumps require inlet pressures greater than atmospheric or are intended for high altitude operation also incorporate such systems.

In view of the foregoing factors and conditions characteristic of available apparatus for separating gases from liquids, it is a primary object of the present invention to provide a new and improved degassifying device and method not subject to the disadvantages enumerated above and having means for reducing the gas content of the fluid in a pressurized system to a predetermined subatmosphere level while maintaining complete integrity of the system.

Another object of the invention is to provide a device for degassing fluids having a collection and storage chamber within the device for retaining separated gases.

Still another object of the invention is to provide a device of the type described in which a vacuum is created by an integral depressurizing pump to cause entrained gas bubbles within a fluid to enlarge whereby they may be collected and stored on the inlet side of a filter thereby preventing reabsorption of the gas in the degassed fluid.

A further object of the invention is to provide a device of the type described which is designed and arranged in such a manner that the filter element may be removed for servicing without disturbing any fluid connections.

Yet another object of the invention is to provide a device of the type described wherein degassing of a liquid is accomplished by a fine filter with a vacuum serving to enlarge the bubbles of gas in the liquid and wherein an integral depressurizing pump is operated by the fluid from the same system as that being degassed.

Another object of the invention is to provide an improved method for removing gases from liquids.

Another object of the invention is to provide a method for removing gases from liquids by subjecting the liquid to a subatmospheric pressure to expand the gas entrained therein and then passing the depressurized liquid through a filter which retains the gas bubbles on its upstream side.

Yet another object of the present invention is to provide an improved ground cart for servicing hydraulic systems.

A still further object is to provide a device employing baffle means to prevent reabsorption of gas in degassed fluid.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawings to which they relate.

Essentially, the degassifier of the present invention comprises a vacuum chamber into which liquid containing entrained gas is fed under pressure. As the liquid enters the vacuum chamber, the bubbles of entrained gas are enlarged. A separator element having, for example, a fine wire mesh screen is interposed between the inlet and outlet of the chamber such that the liquid will readily pass through the separator element while the gas bubbles remain upstream thereof. A gas collection chamber is provided within the device for storing the separated gas for limited periods of time. A vacuum is formed in the chamber by means of an aspirator or fluid jet pump which is located in the upper area of the device and which may be operated by the fluid from the same system as that being degassified. Thus, the liquid which passes through the separator and into the outlet conduit is degassified, with the gas evolving from the fluid upstream of the separator being collected in the collection chamber. The degassed liquid and fluid from the depressurization combine and pass out of the degassifier in a single outlet.

Referring now to the drawings in which presently preferred embodiments of the invention are illustrated:

FIGURE 1 is a plan view of a gas-liquid separator of the invention;

FIGURE 2 is a vertical, partial cross-sectional view, with parts shown in elevation, taken along essentially line 2—2 of FIGURE 1;

FIGURE 3 is an elevational view, partially in cross-section, of the device of FIGURE 1 showing a valve of the invention connected thereto;

FIGURE 4 is a transverse, cross-sectional view taken along line 4—4 of FIGURE 2;

FIGURE 5 is a transverse, cross-sectional view taken along line 5—5 of FIGURE 2; and

FIGURE 6 is an elevational view, showing somewhat schematically a ground cart of the invention employing a degassifier of the invention.

Referring again to the drawings and particularly to FIGURES 1—5, a degassifier of the present invention, generally designated 10, includes an air extraction or separation chamber 12, an air or gas storage chamber 14, a separator element 15 and a depressurizing pump 16.

The air extraction chamber 12 has an encompassing side wall 20, an open top 21 and a bottom wall 22. The bottom wall 22 is provided with an upstanding boss 23 which is internally threaded to receive a drain plug 24. A fluid inlet port 26 is mounted in the side wall 20 and communicates with a passageway 28 which may, for example, be closed at its top by means of a plug 29 and is open at its bottom forming a fluid outlet port 30 adjacent the bottom wall 22. The side wall 20 carries external threads 32 at its upper end which threadedly engage internal threads 34 on the structure defining the air chamber 14.

The structure generally including the air chamber 14 includes an encompassing side wall 36, a closed top wall 38 and an open bottom 39. A fluid inlet port 40 is defined in the side wall 36 and includes a flow restriction 41 which communicates with an annular passageway 42. The annular passageway 42 assures that the inlet port 26 of the structure of the separation chamber 12 will be placed in fluid communication with the inlet port 40 even though the port 26 may be out of register with the port 40 when the chamber 12 is threaded into tight engagement with the chamber 14. An annular channel 44 is provided at the open end of the chamber 14 and serves as a seat for a conventional annular seal 45 which forms a fluid-tight seal with the wall 20. A gas outlet port 46 (FIGURE 3), a fluid inlet port 47 and a fluid outlet port 48 are provided in the top wall 38. The inlet port 47 and the outlet port 48 communicate with a common passageway 50 which, in turn, is in fluid communication with the extraction chamber 12 through a passageway 52. The passageway 52 is formed by casting a hollow member 54 integrally with the top wall 38. The member 54 is supported at its lower end by means of a web 56 which connects it to the side wall 36 and serves as a baffle for retaining collected air in the storage chamber. The web, or baffle 56 has a series of interrupted openings to allow the passage of extracted air and is sloped to enhance the movement of air upward. An annular collar 58 depends into the air extraction chamber 12 and may be cast as an integral part of the member 54 and 56 to provide a guide for locating the separator element 15 and a sealing surface between the air chamber 12 and the separator element. The underside of the web 56 forms a land 60 against which the separator element 15 may seat.

The separator element 15 is adapted to pass a liquid while retaining enlarged air bubbles. One such element which has been found suitable for aircraft hydraulic fluid comprises a sintered wire mesh screen 61 having a 10-micron mesh and includes a closed bottom wall 62, and an open top forming an upstanding annular collar 63

which encompasses the depending annular collar 58. The collar 63 is positioned in abutting relation with the land 60. An annular seal 64 is interposed between the collars 58 and 63 to prevent leakage of fluid past the downstream side of the separator element 15. A compression spring 65 surrounds the boss 23 and bears against the closed bottom 62 of screen 61 to maintain separator 15 in engagement with the land 60.

The depressurizing pump 16 is shown for purposes of illustration, but not of limitation, as comprising a jet pump or aspirator having a nozzle portion 66 and a throat portion 68. The nozzle portion 66 is mounted in the passageway 50 and has one end abutting a shoulder 69 adjacent the fluid inlet port 47. The other end of the nozzle 66 is disposed superjacent the passageway 52 and has a plurality of ports 70 disposed about the periphery thereof. A reduced throat section 71 is provided in the nozzle portion 66 in such a manner that it is encompassed by the ports 70. A filter element 73 is mounted in the nozzle portion 66 to filter the incoming fluid. A ribbed collar 73a having a protuberance 73b which engages the filter element 73 may typically be employed to retain the element 73 in position within the nozzle 66. Alternatively, the housing may include a simple retainer means. An annular seal 74 may be employed to prevent leakage of fluid past the nozzle portion 66 and it encompasses the nozzle portion 66 in sealing engagement with the passageway 50.

The throat portion 68 is threaded or otherwise inserted into the outlet port 48 so as to abut the nozzle portion 66, retaining it in position in the passageway 50. An annular seal 75 is employed to place the throat 68 in sealing engagement with the passageway 50. The throat portion 68 also includes an internally threaded discharge port 76 to which a return line 77 may be connected for returning treated liquid to the system being treated.

Referring now particularly to FIGURE 3, a bleed valve 80 may be employed to evacuate the air storage chamber 14. It comprises a valve body 82 in which a fluid inlet port 83, a fluid outlet port 84, a gas inlet port 85, and a gas outlet port 86 are provided. The ports 83, 84, 85 and 86 communicate with a common passageway 87 in which a spool 88 is slidably mounted. The spool 88 includes a first land 89 and a second land 90 and is biased with a spring 91 in such a manner that the second land 90 is normally offset from the fluid inlet port 83 and the fluid outlet port 84. Under this condition, the first land 89 closes the gas inlet port 85 and the gas outlet port 86. A button 92 is provided on the end of the spool 88 so that it may be displaced to the left, as viewed in FIGURE 3, when it is desired to purge the air chamber 14, as will be hereinafter described in detail. The fluid inlet port 83 is connected to a first bypass line 94 which bleeds from the main hydraulic system at its normal operating pressure, a portion of the liquid to be used to operate the depressurizing pump. A line 95 connects the liquid outlet port 84 with the liquid inlet port 47 of the degassifier 10 so that the pressurized liquid may be supplied to the depressurizing pump 16 at the normal operating pressure of the liquid. The air outlet port 86 is vented to atmosphere through a pipe 97 and a conduit 98 connects the outlet port 46 of the gas storage chamber 14 with the air inlet port 85 of the valve 80. A second bypass line 99 connects the liquid inlet port 40 of the degassifier 10 with the liquid to be degassed which is in the return side of the system and is therefore at a substantially reduced pressure. When the degassifier 10 is employed for degassing the hydraulic fluid employed in an airplane, the normal operating pressure of the fluid is at approximately 3,000 p.s.i.g. and the return pressure of the fluid is approximately 40 p.s.i.g. Therefore, the bypass line 94 bleeds hydraulic fluid from the main hydraulic system at 3,000 p.s.i.g. and feeds it into the depressurizing pump 16 at this pressure. The bypass line 99 simultaneously

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feeds hydraulic fluid to be deaerated to the degassifier 10 at a pressure of approximately 40 p.s.i.g.

Of course, it is apparent that the line 99 need not bypass line bleeding off a portion of the liquid flow, but may be placed directly in the system being treated to accept a full flow of the liquid to be degassified. In this case, the degassifier 10 would have a larger capacity and the air storage chamber 14 would be much larger. Obviously, other means of shutting off the pump and bleeding the system, such as two separate valves, may be used. The embodiment of the degassifier 10, shown for purposes of illustration, but not of limitation, is designed for use on aircraft where weight considerations dictate the design of equipment employed thereon. Consequently, the degassifier 10 is designed to treat only approximately ¼ gallon of hydraulic fluid per minute via the bypass lines. To treat the full flow of fluid not only requires a larger degassifier 10, but also requires the use of additional cooling equipment to extract the additional heat imparted to the fluid by the aspirator type depressurizing pump.

The air storage chamber 14 is purged by depressing the button 92 (see FIGURE 3), thereby displacing the spool 88 to the left. The lands 89 and 90 are positioned on the spool 88 in such a manner that high pressure flow to pump 16 is terminated slightly before the land 89 vents the chamber 14 so that the incoming flow of liquid through the inlet 40 will start rising upwardly into the chamber 14 to pressurize it sufficiently that the air stored therein will flow out of chamber 14 against the atmospheric pressure which will prevail as soon as land 89 opens a flow path.

Referring now to FIGURE 6, a ground cart of the invention, generally designated 100, includes a wheeled cart 102 on which is mounted a reservoir 104, a first pump 106 and a second pump 108.

The ground cart 100 is designed to check the operation of the hydraulic system of an airplane, missile, etc., while it is on the ground and must, therefore, supply hydraulic fluid to the airplane's hydraulic system at 3,000 p.s.i.g. and receive fluid from the system at 40 p.s.i.g. To assure that air is not introduced into the fluid being supplied to the airplane, the reservoir 104 is maintained under a depressurized condition so that a substantial vacuum will exist therein above the hydraulic fluid being pumped therefrom. A conduit 110 connects the inlet side of the pump 106 to the reservoir 104 and a conduit 112 connects the discharge side of pump 106 to the inlet side of the pump 108. The pump 106 is a secondary pump which pumps fluid at a low pressure and is employed to assure that the primary pump 108 will receive fluid at an inlet pressure sufficient to generate 3,000 p.s.i.g. The pump 108 discharges through a conduit 113 to the airplane being tested. A return line 114 returns the hydraulic fluid from the airplane to the reservoir 104. A degassifier 116 may be employed to remove air from the hydraulic fluid being supplied to the airplane and may be identical to the degassifier shown and described in FIGURES 1-4, except that it usually employs larger components. A conduit 118 receives flow from the conduit 114 and supplies the degassifier 116 with the fluid to be treated. A conduit 119 receives flow from the conduit 113 to operate a depressurizing pump, not shown. A conduit 120 then returns treated fluid to the reservoir 104.

The method of the invention and operation of the device will be readily understood from the following example: Airplane hydraulic fluid is supplied to degassifier 10 through the fluid inlet port 40 at a predetermined pressure, e.g., 40 p.s.i.g. The fluid flows through the restriction 41, down the passageway 28 and through outlet port 30 into the bottom of the separation chamber 12, filling not only the chamber 12, but the air storage chamber 14 as well. Simultaneously, fluid at the normal operating pressure of the system, e.g., 3,000 p.s.i.g., is supplied to the depressurizing pump 16 through the fluid inlet 47.

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In flowing through the depressurizing pump 16, the fluid creates a subatmospheric pressure within the separation chamber 12 causing air entrained in the fluid entering the chamber 12 to be expanded into large bubbles. The enlarged air bubbles do not pass through the separating element 15. However, the fluid does readily flow there-through, passing upwardly through passageway 52, port 70, throat portion 68 and discharge port 76. It is then returned to the aircraft hydraulic system through return line 77. The separated air bubbles pass upwardly into the air storage chamber 14, displacing the liquid therefrom, which then flows downwardly and through the separator element 15.

At the conclusion of the run, the air storage chamber 14 is purged of air by depressing button 92. This terminates the flow of fluid to the depressurizing pump 16 so that the air chamber 14 is again filled with fluid which forces the stored air out through the air outlet port 46, line 98, ports 85 and 86, and pipe 97 to atmosphere.

While the particular apparatus and method herein shown and described in detail are fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that they are merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction, design or operating steps herein shown and described other than as defined in the appended claims.

What is claimed is:

1. A gas separator for removing gas from liquids comprising:

- (a) means defining a gas extraction chamber;
- (b) fluid inlet means and gas outlet means in said extraction chamber means spatially separated from one another for respectively admitting a fluid under a predetermined pressure and removing separated gas;
- (c) depressurizing means in fluid communication with said extraction chamber for establishing a subatmospheric pressure therein;
- (d) passage means in said extraction chamber means leading from said last-mentioned means through said depressurizing means and having a liquid outlet spatially separated from said gas outlet means; and
- (e) a separator element mounted in said extraction chamber means, said element having an upstream side in fluid communication with said fluid inlet and a downstream side in fluid communication with said depressurizing means, said separator element being pervious to said fluid and impervious to gas bubbles entrained therein when said bubbles are expanded by being exposed to said subatmospheric pressure upon entering said extraction chamber.

2. The gas separator of claim 1 including means defining an air storage chamber, the storage chamber being in fluid communication with said gas extraction chamber upstream of said separator element.

3. The gas separator of claim 2 further including baffle means between said gas extraction chamber and said air storage chamber, said baffle means being sloped inward toward said air storage chamber.

4. The gas separator of claim 1 wherein said depressurizing means comprises an aspirator having an inlet end in fluid communication with a source of liquid under pressure, a reduced throat section, and passage means for communicating said throat section with the downstream side of said separator element.

5. The gas separator of claim 1 wherein said separator element comprises a screen having a mesh sufficiently fine to be impervious to said expanded gas bubbles.

6. The gas separator of claim 1 wherein said separator element comprises a generally cylindrical member having a closed bottom and an open top, said open top being in fluid communication with said depressurizing means, whereby the interior of said element constitutes said downstream side.

7. A degassifier comprising:
- (a) means defining an air extraction chamber having a closed bottom, an open top and a liquid inlet port;
 - (b) means defining an air storage chamber having a partially open bottom and a closed top and being connected by its open bottom to the open top of said air separation chamber; 5
 - (c) means containing a passageway transversely oriented in the closed top of said storage chamber and having a liquid inlet and a liquid outlet; 10
 - (d) an aspirator mounted in said passageway in fluid communication with said liquid inlet;
 - (e) conduit means placing said aspirator in fluid communication with said air extraction chamber for creating a subatmospheric pressure therein; and 15
 - (f) a filter element mounted in said air extraction chamber and having a closed bottom and an open top, said open top being in fluid communication with said aspirator through said conduit means, said element being pervious to said liquid and impervious to gas bubbles entrained therein when said bubbles are expanded by being exposed to said subatmospheric pressure upon entering said extraction chamber. 20
8. In combination with the hydraulic system of an aircraft having a first conduit supplying hydraulic fluid to components to be operated thereby and a second conduit returning fluid from said components, a degassifier comprising: 25
- (a) a housing having a continuous side wall, a closed bottom and a closed top; 30
 - (b) first inlet means in said housing for placing said housing in fluid communication with said second conduit;
 - (c) second inlet means in said closed top for connecting said degassifier to said first conduit; 35
 - (d) an aspirator mounted in said closed top in fluid communication with said second means adapted to

- create a subatmospheric pressure in a portion of said housing;
- (e) said first conduit placing the discharge end of said aspirator in fluid communication with the interior of said housing; and
 - (f) a separator element mounted in said housing, said element having an upstream side in fluid communication with said first inlet means and a downstream side in fluid communication with said conduit, said separator element being pervious to said liquid and impervious to gas bubbles entrained therein when said bubbles are expanded by being exposed to the subatmospheric pressure created by said aspirator.
9. A method of degassifying the hydraulic fluid in an aircraft hydraulic system having a high pressure supply line and a low pressure return line comprising the steps of:
- (a) bleeding fluid from said low pressure line into a chamber maintained at a negative pressure to expand the gas bubbles entrained in said fluid;
 - (b) passing said bled fluid from said chamber through a filter element which is pervious to hydraulic fluid and impervious to said expanded gas bubbles; and
 - (c) collecting said gas bubbles in a gas storage chamber which is maintained at a negative pressure.

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