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LIQUID INSPECTION SYSTEM AND APPARATUS

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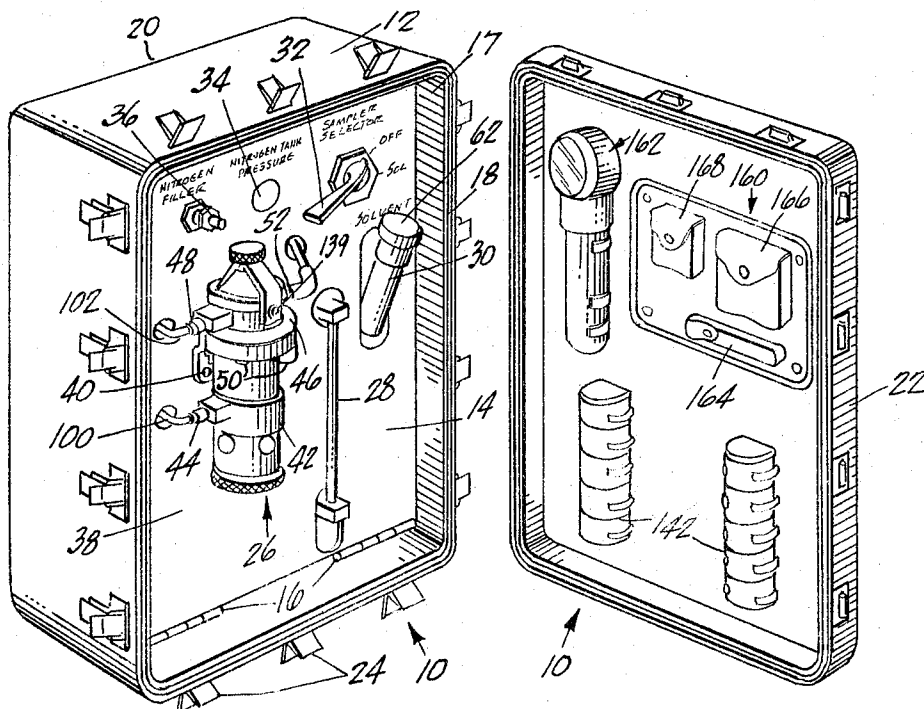


Fig. 1

Fig. 2

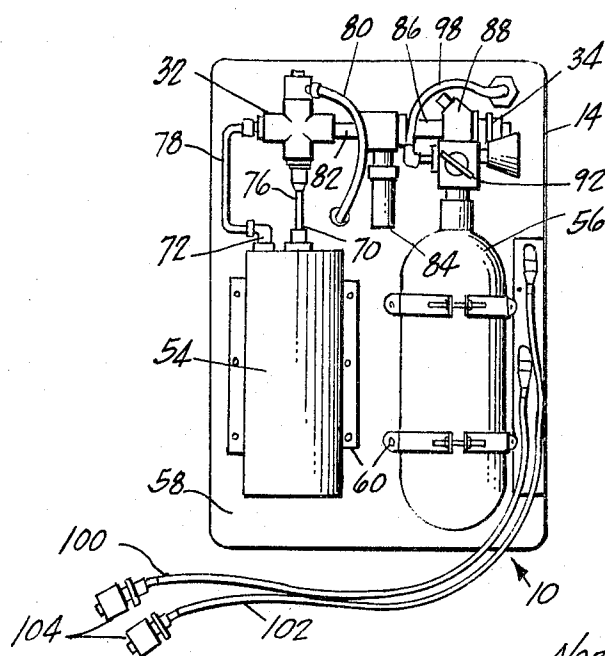


Fig. 3

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LIQUID INSPECTION SYSTEM AND APPARATUS
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The present invention relates generally to liquid inspection systems and apparatus for determining the presence of contaminants in liquids and more particularly to a modification of the systems and apparatuses shown in copending applications Serial No. 134,687 filed September 12, 1961, now abandoned, and Serial No. 197,198 filed May 22, 1962, these prior applications being assigned to the common assignee hereof.

The successful operation of many systems used to conduct liquids depends upon maintaining the system in a contamination-free condition. For example, hydraulic fluids utilized to operate valves, hydraulic actuators, positioners and the like, on aircraft, missiles and the like, must be maintained in a contamination-free condition for satisfactory operation of the devices.

Contaminants that are usually found in hydraulic fluids and the like generally take the form of organic and inorganic particles which find their way into the hydraulic fluid prior to placement in the system in which it is used, or are generated within the system by wear of the moving parts. Although the hydraulic fluids used in the described systems are carefully cleaned and filtered prior to injection into the system, contaminants in the order of 0.1 to 10 microns, or larger, may find their way into the system or be generated within it. These contaminants, while affecting operation of equipment associated with hydraulic systems, are extremely difficult to detect in the absence of relatively elaborate laboratory facilities. The problem is further complicated by the fact that it is desirable to detect the contaminants in certain hydraulic fluid systems while the systems are in operation and, in some cases, while the systems are pressurized. Under these conditions, the contaminants are generally maintained in suspension.

Prior to the liquid inspection systems and apparatuses of said co-pending applications, hydraulic fluid systems were examined or checked for contaminants by removing some fluid from the system for examination in a remote laboratory.

The systems and apparatuses of said co-pending applications, on the other hand, are connectible directly into the hydraulic system to be inspected so that a sample need not be taken from the system for subsequent examination in a laboratory.

The liquid inspection system and apparatus of the present invention is of the type which may be incorporated directly into the hydraulic system to be examined, but is modified in certain respects from those shown in said co-pending applications.

Accordingly, it is one important object of the present invention to provide a liquid inspection system and apparatus which is a modification of the systems and apparatuses shown in co-pending applications Serial No. 137,687 filed September 12, 1961 (now abandoned) and Serial No. 197,198 filed May 22, 1962.

It is another important object of the present invention to provide a system and apparatus for determining the presence of contaminants in a liquid not subject to the disadvantages of prior art systems and apparatuses.

Another object of the present invention is to provide a contaminant determining system and apparatus used in connection with liquid systems, while such systems are in operation and at the site of operation of the system.

Another object of the present invention is to provide

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a new and useful system and apparatus of the type described for determining the presence of contaminants in a liquid.

A still further object of the present invention is to provide a system and apparatus of the type described for determining contaminant content in liquids wherein a sample of the liquid may be obtained from an operating system and examined without introducing additional contaminants to the liquid under examination.

According to the present invention, an apparatus of the invention is attached to the hydraulic pressure and return lines of the system to be examined thereby trapping a sample of the hydraulic fluid within the apparatus. The hydraulic-fluid sample is then flushed with a filtered solvent and filtered through a field monitor which contains a filter patch. Dry nitrogen or the like is then employed to dry the patch. The field monitor is then removed from the apparatus and a comparison check made with an acceptable standard filter patch using a magnifier. The field monitor includes a plastic housing assembly having an inlet port which may be quickly snapped into place on a drain poppet at the bottom of the apparatus.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of the apparatus of the present invention mounted in its carrying case;

FIG. 2 is a perspective view of a cover for the carrying case of FIG. 1 showing certain components of the apparatus in position therein;

FIG. 3 is an elevational view of the portion of the apparatus of the present invention which is housed in the bottom of the carrying case of FIG. 1;

FIG. 4 is a cross-sectional view showing somewhat schematically the operating circuits of the apparatus of the present invention with certain parts thereof shown in a first operating condition; and

FIG. 5 is an enlarged cross-sectional view of certain parts of FIG. 4 in a second operating condition.

Referring again to the drawings, the apparatus of the present invention comprises a test kit, generally designated 10, and includes a carrying case 12 in which a wall partition member 14 is swingably mounted on hinges 16. The carrying case 12 has an open top 17, an encompassing sidewall 18 and a closed bottom wall 20. A cover member 22 may be snapped into position on the carrying case 12 by snaps 24 to close the open top 17.

When the cover 22 is removed from case 12 as shown in FIG. 2, a hydraulic fluid sampler 26, a sight glass 28, a solvent-tank filler neck 30, a selector switch 32, a nitrogen tank pressure gauge 34 and a nitrogen inlet fitting 36 are exposed.

The hydraulic fluid sampler 26 is attached to a front face 38 of the partition 14 by suitable bolts, such as the one shown at 40. The hydraulic fluid sampler 26 includes a lower housing member 42 in which a hydraulic fluid inlet port 44 is mounted and an upper housing member 46 in which a hydraulic fluid outlet port 48 is mounted. The housing members 42 and 46 are connected together as by bolts 50. The upper housing member 46 also includes a solvent inlet port 52.

A solvent tank 54 (FIG. 3) and a pressurized nitrogen tank 56 are attached to a rear face 58 of the partition 14 by suitable bolts 60. The solvent tank 54 includes the filter neck 30 (FIG. 1) which extends through the partition 14 to the front face 38, as previously described. The

filler neck 30 is normally closed with a cap 62. The solvent tank 54 (FIG. 4) also includes an encompassing sidewall 64, a closed bottom wall 66 and a closed top wall 68. A nitrogen inlet port 70 is mounted in the top wall 68 for admitting nitrogen under pressure to the tank 54 and a solvent outlet port 72 is mounted in the top wall 68 in communication with a depending stand pipe 74 through which solvent under pressure flows from the tank 54. A conduit or line 76 connects the nitrogen inlet port 70 to a port 33b in the selector switch 32 and a conduit or line 78 connects the outlet port 72 to a port 33a in the switch 32. A conduit or line 80 connects the switch 32 to the solvent inlet port 52 and a conduit or line 82 connects the switch 32 to a relief valve 84. A conduit or line 86 connects the relief valve 84 to a nitrogen pressure regulator 88 which, in turn, is connected to the nitrogen cylinder 56 by a conduit or line 90 through a shutoff valve 92. The valve 92 includes an L-fitting 94 to which the nitrogen inlet 36 is connected by a conduit 98.

The sight glass 28 is connected to the solvent tank 54 to indicate the level of solvent therein. Flexible conduits 100 and 102 are connected to the hydraulic fluid inlet port 44 and the outlet port 48, respectively. The flexible conduits 100 and 102 each carry a hose fitting 104 (FIG. 3) which may be employed to connect the hydraulic fluid sampler 26 to a hydraulic system, not shown, to be tested.

Fluid to be tested flows through the flexible conduit 100, and the inlet port 44 unseating a poppet valve 106 (FIG. 4). The fluid then flows into a chamber 108 in the sampler 26. The chamber 108 extends from the lower housing member 42 into the upper housing member 46. The lower housing member 42 includes a partition 109 in which an outlet port 110 is mounted. The port 110 is normally closed by a poppet valve 112 shown seated in FIG. 4 by a leaf spring 114. A partition 115 is mounted in the upper housing member 46 and is provided with an inlet port 116 which is normally closed by a poppet valve 118 biased to a closed position by a spring 120. An outlet port 122 is also mounted in the upper housing member 46 and is normally closed by a ball-type check valve 124 which is maintained in a seated condition by a spring 126. Since the valves 112 and 118 are closed as shown in FIG. 4 when the fluid enters the chamber 108, it must flow upwardly in the direction of arrow 128 unseating the check valve 124 and flowing through the outlet port 48 into the return conduit 102. This fills the chamber 108 with fluid to be tested after which flow through the inlet conduit 100 is terminated.

The sampler 26 is put into condition to test the fluid in chamber 108 by placing a filter patch and pad assembly 130 on top of a support disc 132 in the open top 133 of upper housing member 46 above partition 115. After the filter patch 130 is in position, a cover member 134 is placed on the top of the upper housing member 46 and sealed thereto with an O-ring 136. The cover member 134 is maintained in position by a yoke and screw assembly 138 which is swingably mounted on the upper housing member 46 by suitable bolts, such as the one shown at 139 in FIG. 1.

The sampler 26 is further conditioned to test the fluid in chamber 108 by removing a base adapter ring 140 from its threaded engagement with the open bottom 141 of lower housing member 42 and connecting a field monitor 142 (FIG. 5) to the outlet port 110. The field monitor 142 includes an inlet neck 144 which carries an O-ring 146. The inlet neck 144 engages the poppet valve 112 unseating it to permit flow of fluid from the chamber 108 through the outlet 110 and into the field monitor 142. The O-ring 146 prevents leakage of fluid past the inlet neck 144.

The field monitor 142 also includes an outlet neck 148 to which a flexible tube 150 may be attached to direct the fluid flowing from chamber 108 to a waste receptacle, not shown. A test patch and pad assembly 152 is supported in the field monitor 142 on a disc 154. The filter patches

130 and the test patches 152 may be of any suitable material having a porosity commensurate with the size of contaminant particles that are desired for collection. In testing hydraulic fluid at missile installations, openings in the order from 0.1 to 10 microns have been satisfactory. Particularly, a test patch suitable for such testing is that manufactured by the Millipore Filter Corporation of Bedford, Massachusetts, and sold under the trade name of Millipore filter. This particular test patch is in the order of 0.010 inches to 0.020 inches in thickness, is usually white in color and is made from a fibrous material having a high void to solids ratio. Particularly, the voids may occupy 70 to 80 percent the area of the filter while still retaining the 0.1 to 10 micron openings. The field monitor consists of the same filter membrane enclosed in a clear plastic capsule, and is also manufactured by Millipore Filter Corporation.

The filter patch 130 is employed to filter solvent from tank 54 and nitrogen from tank 56 which enters the open top 133 above the filter 130 through inlet port 52 and a passageway 156. This is to prevent contaminants present in the solvent or nitrogen from appearing on the test patch 152 in field monitor 142.

Referring now particularly to FIG. 2, a supply field monitor 142 is stored in the cover 22 in which a pouch 160 and a 5× power viewer 162 are also mounted. The pouch 160 includes a pocket 165 in which a pair of forceps or the like (not shown) may be stored, a pocket 166 in which additional filter patches 130 may be stored and a pocket 168 in which additional test patches may be stored.

Operation of the device of the present invention will be readily understood.

The test kit 10 may, for example, be used to monitor periodically for contamination in the hydraulic fluid used in a hydraulic system test stand (not shown). A hydraulic system test stand is sometimes used for testing various missile components. The hydraulic fluid becomes contaminated by being pumped through these missile components and returned to the test stand. A built-in self-cleaning system is incorporated in the hydraulic test stand and a periodical check with the test kit 10 is used to check the validity of the self-cleaning system. The validity of the self-cleaning system is checked by taking a sample of hydraulic fluid therefrom and testing it to determine the particle contamination content in the hydraulic fluid. This sample may be procured by connecting the flexible conduit 100 to the hydraulic pressure line of the test stand while the flexible conduit 102 is connected to the return line of the test stand to admit hydraulic fluid under pressure into chamber 108 of sampler 26 when valves 112 and 118 are closed.

The nitrogen gauge 34 is then checked to make sure that it indicates that the nitrogen tank 56 is from one-half full to full.

The sample selector 32 is then checked to make sure it is in its "off" position. The sight gauge 28 on the solvent tank 54 is checked to insure that it indicates a minimum of 2 inches of fluid in the solvent tank. If the sight glass 28 shows less than 2 inches, the solvent tank 54 must be filled through filler neck 30 with a clean solvent such as Freon TF (113) commercial grade solvent to within ½ inch of the top of the sight glass 28. Filled with solvent and compressed nitrogen, the sampler is independent of any external power such as electricity or pneumatic pressure or vacuum.

The next step is to verify that hydraulic pressure has been disconnected from the sampler 26. The yoke assembly 138 can then be loosened and swung aside so that the cover member 134 may be removed to expose the filter patch 130. A new filter 130 is required after about every third test and extra filter patches may be obtained from pocket 166 in the lid 22. Forceps, which may be stored in pocket 164, may be used to place a new filter

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patch 130 in upper body member 46. The base adapter ring 140 is then removed and a field monitor 142 is taken from lid 22 and examined to assure that it has a test patch 152 properly mounted therein. The field monitor 142 is positioned in the base adapter ring 140 which is then tightened into the open bottom 141 of lower housing member 42 in such a manner that neck 144 engages poppet valve 112 to unseat it. The hose 150 may then be attached to the neck 148 on field monitor 142 and the free-end of hose 150 may be placed in a waste tank, not shown.

The nitrogen valve 92 may then be opened and the sample selector switch 32 moved to the position marked "solvent" on partition 14. With the selector switch 32 in the position marked "solvent," the port 33a of selector 32 places conduit 78 in fluid communication with fluid conduit 80 and the port 33b places the conduit 76 in fluid communication with the conduit 82. Since the nitrogen valve 92 is open, nitrogen under pressure flows from tank 56 through conduit 90, pressure regulator 88, line 86, relief valve 84, line 82, port 33b, and line 76 into solvent tank 54 pressurizing it. Solvent then flows from tank 54 through stand pipe 74, outlet port 72, conduit 78, port 33a, conduit 80, inlet port 52, passageway 156, and filter patch 130. The pressure of the solvent then unseats poppet valve 118 and flows into chamber 108 forcing the hydraulic fluid therein contained through outlet 110 in the bottom of sampler 26, the field monitor 142 and the hose 150. Hydraulic fluid is allowed to drain through the hose 150 until the color of the fluid disappears and clear solvent is observed. The sample selector switch 32 is then moved to the "nitrogen" position on partition 14 to place the nitrogen bottle 56 in fluid communication with the line 80. Nitrogen from tank 56 then flows through line 90, valve 92, regulator 88, line 86, relief valve 84, line 82, port 33b, line 80, inlet port 52, passageway 156, filter 130, check valve 118, chamber 108, outlet port 110, test patch 152, and line 150 to waste. The nitrogen is permitted to flow a minimum of one minute and a maximum of two minutes to dry the test patch 152. The test patch 152 must be thoroughly dried. More economical usage of nitrogen results when the selector switch 32 is switched off and on intermittently while residual solvent drains from the sampler 26.

The sampler selector switch 32 is then moved to its off position and the field monitor 142 is removed from the sampler 26 by loosening base adapter ring 140. The 5× power viewer 162 is then positioned to view a standard test patch, not shown, and the test patch 152 from the field monitor simultaneously so that the two patches may be compared. If the test patch 152 indicates contamination above acceptable limits, it becomes necessary to recirculate the hydraulic fluid through the hydraulic test stand filtering system.

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

I claim:

1. Apparatus for determining the presence of contaminants in a liquid comprising:

- a fluid housing having an open bottom and an open top;
- a first liquid inlet port mounted in said housing above said open bottom;
- a first poppet valve normally closing said first inlet port;
- a first partition mounted in said housing intermediate said first inlet port and said open bottom;
- a first liquid outlet port mounted in said first partition in communication with said open bottom;

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- a second poppet valve normally closing said first outlet port;
 - a second liquid outlet port mounted in said housing intermediate said first inlet port and said open top;
 - a check valve mounted in said second outlet port for permitting flow of liquid from said housing while preventing back flow into said housing;
 - a second partition mounted in said housing intermediate said open top and said second outlet port;
 - a second liquid inlet port mounted in said second partition for placing said open top in fluid communication with said housing;
 - a normally closed poppet valve mounted in said second inlet port for permitting flow of fluid into said housing while preventing flow of fluid from said housing;
 - a first filter patch mounted in said open top above said second inlet port;
 - a third inlet port mounted in said housing in fluid communication with said open top above said first filter patch;
 - a removable cover member for closing said open top above said first filter patch; and
 - a field monitor positionable in said open bottom, said field monitor housing a second filter patch and including an inlet neck engageable with said first outlet valve to unseat said valve and permit flow of liquid from said housing through said first outlet port and said second filter patch.
2. The apparatus of claim 1 including a solvent containing tank in fluid communication with said third inlet port for directing a solvent through said first filter patch, said second inlet port, said first outlet port and said second filter patch.
3. The apparatus of claim 2 including a nitrogen-containing tank in fluid communication with said solvent tank to pressurize said solvent tank.
4. The apparatus of claim 3 including a selector switch for selectively placing said nitrogen tank in fluid communication with said solvent tank and simultaneously placing said solvent tank in fluid communication with said third inlet port, and for placing said nitrogen tank in fluid communication with said third inlet port.
5. The apparatus of claim 4 wherein said solvent tank and said nitrogen tank are mounted on one side of a wall partition member and said housing is mounted on the other side of said wall partition member.
6. The apparatus of claim 5 wherein said wall partition member is swingably mounted in a carrying case having an open top and a closed bottom.
7. The apparatus of claim 6 including a lid for closing said open top of said case.
8. Apparatus for determining the presence of contaminants in a liquid, comprising:
- a carrying case including an open top and a closed bottom, and having a wall partition member swingably mounted in said case;
 - a fluid housing mounted on one side of said wall partition member and including
 - a filter which is pervious to said liquid and impervious to said contaminants,
 - means for mounting said liquid filter to said housing,
 - means for conducting a quantity of said liquid through said liquid filter, said contaminants being retained by said liquid filter, and
 - means for thereafter conducting a solvent through said liquid filter to remove substantially all residue of said liquid from said liquid filter whereby said contaminants will be exposed for inspection, said solvent conducting means including means for filtering said solvent prior to passage thereof through said liquid filter; and
 - a solvent containing tank in communication with said solvent conducting means, said solvent tank being

- mounted on the other side of said wall partition member.
9. Apparatus for determining the presence of contaminants in a liquid, comprising:
- a carrying case including an open top and a closed bottom, and having a normally horizontal wall partition member swingable to a vertical position mounted in said case; 5
 - a fluid housing mounted on the normally top side of said wall partition member and including 10
 - a filter which is pervious to said liquid and impervious to said contaminant,
 - means for mounting said liquid filter to said housing,
 - means for conducting a quantity of said liquid through said liquid filter, said contaminants being retained by said liquid filter, and 15
 - means for thereafter conducting a solvent and then a gas through said liquid filter to remove substantially all residue of said liquid from said liquid filter and dry the same whereby said contaminants will be exposed for inspection, said solvent and gas conducting means including means for filtering said solvent and gas prior to passage thereof through said liquid filter; and 20
 - a solvent containing tank and a gas containing tank in communication with said solvent and gas conducting means, said solvent tank and said gas tank being mounted on the normally bottom side of said wall partition member. 25
10. Apparatus for determining the presence of contaminants in a liquid, comprising:
- a carrying case including an open top and a closed bottom, and having an inner wall partition member mounted in said case; 30
 - a lid for closing said open top of said case; 35

- a fluid housing connected to the normally top side of said wall partition member and including
 - a filter which is pervious to said liquid and impervious to said contaminant,
 - means for mounting said liquid filter to said housing,
 - means for conducting a quantity of said liquid through said liquid filter, said contaminants being retained by said liquid filter, and
 - means for thereafter conducting a solvent and then a gas through said liquid filter to remove substantially all residue of said liquid from said liquid filter and dry the same whereby said contaminants will be exposed for inspection, said solvent and gas conducting means including means for filtering said solvent and gas prior to passage thereof through said liquid filter; and
- a solvent containing tank and a gas containing tank in communication with said solvent and gas conducting means, said solvent tank and said gas tank being mounted on the normally bottom side of said wall partition member, and said solvent tank having a filler neck and sight glass connected through said wall partition member to be positioned on the normally top side of the same and said gas tank having an inlet fitting connected through said wall partition member to be positioned on the normally top side of the same.

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