

May 28, 1968

T. V. BRABRAND ET AL

3,385,735

METHOD FOR CLEANING HYDRAULIC SYSTEM

Filed Nov. 15, 1962

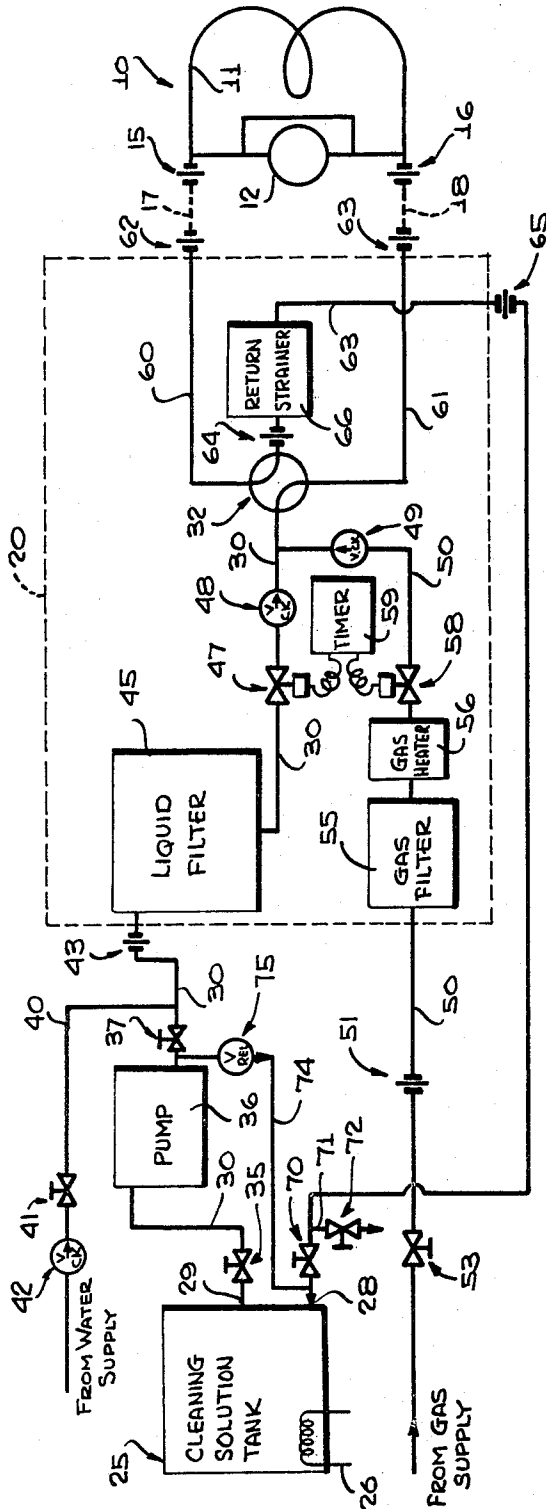


FIG. 1

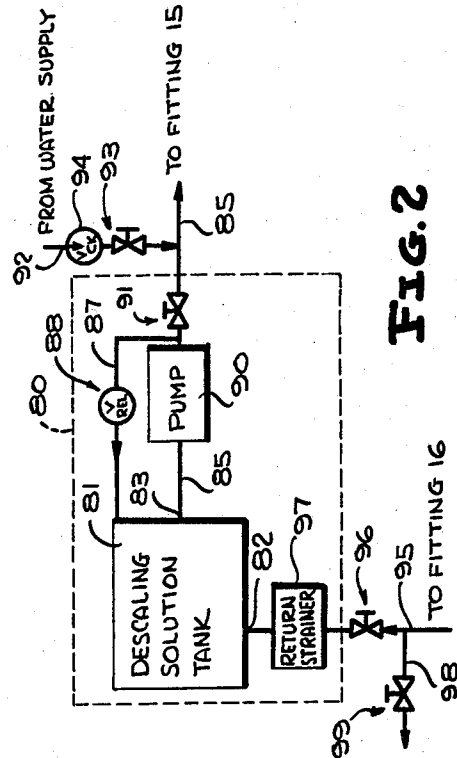


FIG. 2

INVENTORS

THOMAS V. BRABRAND
& RICHARD J. BAUMLER

BY

Shemaker and Mattare
ATTORNEYS

1

3,385,735

METHOD FOR CLEANING HYDRAULIC SYSTEMS

Thomas V. Brabrand and Richard J. Baumler, Newport News, Va., assignors to Newport News Shipbuilding and Dry Dock Company, Newport News, Va., a corporation of Virginia

Filed Nov. 15, 1962, Ser. No. 237,976

2 Claims. (Cl. 134—28)

The present invention relates to a new and novel method for cleaning hydraulic systems, and more particularly to a cleaning of hydraulic systems installed in ships, and more specifically the type of hydraulic system installed in modern day submarines.

When the hydraulic system is installed as for example in a submarine, it must be thoroughly cleaned prior to putting the submarine into service to ensure that there will not be any malfunction of the components controlled by the hydraulic system due to the presence of dirt and other foreign contaminants which might otherwise be present in the hydraulic system.

The problem of properly cleaning these hydraulic systems at the time of installation and prior to putting the ship in service is indeed a difficult and extensive procedure when it is considered that in hydraulic systems of this type there may be as much as 6½ miles of piping connected with approximately 22,000 fittings including about 2250 valves. There are also many other items in the system, and it is essential that once in service the complex system provide long, trouble-free operation.

In the complex machinery as employed in a submarine the simplest failure of a single component of this system can set up a serious chain of events and cause a dangerous condition. The problem is compounded in the instance of submarines since the hydraulic system is prone to become contaminated during installation. This is due to the fact that the space in a submarine is quite limited which makes it difficult for workers to make a good joint in the piping in many instances resulting in many joints with too much flux and which are overheated so as to form oxide inside the pipe.

Material handling is also a problem because of the lack of space causing dirt to enter the components prior to installation. Also, since many workers in different trades are working concurrently near one another situations often arise where an end of a pipe may be left open such that other workers such as welders, grinders or chippers may cause contaminating particles to enter the open end of the pipe.

The flushing procedures for cleaning out such hydraulic systems must be virtually fool-proof and of course must be capable of being carried out by personnel who are not highly technically trained. The extensive procedures involved in flushing out the hydraulic system of a submarine may generally take from four to four and a half months from the time the flushing is started until the system is ready for testing. It is obvious that if the system should be contaminated from testing it will involve a great delay in time and extra consumption of effort to again flush this system so as to free it of contaminants. It thereby becomes essential to provide a method for cleaning the hydraulic system which is as effective as possible. The entire hydraulic system may be broken down into a number of loops which can be separately flushed, each loop of the system being cleaned according to the disclosure of the present invention. Some of the components of the system such as one way check valves must be removed in order to permit the reverse flushing procedures to be carried out and these relatively small components are firstly removed and replaced by suitable fixtures to permit the flushing procedures to be carried out. These small components

2

may be effectively cleaned by ultrasonic cleaning in a well-known manner. Flush blocks may be utilized for replacing control valves and ball valves may also be removed since they tend to score if left in during water flushing and dirt becomes trapped behind the ball and seat assemblies.

Another feature of the method of the present invention is the provision of a procedure for ensuring that the system is tight and will not leak at 1½ times its normal working pressure and furthermore that the assembled system does not leak. It will be apparent to one skilled in the art that many forms of apparatus may be utilized for carrying out the invention, and in fact many separate components may be employed for this purpose. On the other hand, applicants have disclosed a first apparatus for circulating cleaning solution, water and air through the system while a second apparatus is disclosed for circulating an acid solution and water through the hydraulic system.

Each of these apparatuses represents a compact rig arrangement which may for example be mounted on a portable vehicle or the like such that it can be readily transported to a suitable location for carrying out the method of the present invention. These apparatuses represent relatively compact and simple arrangements for efficiently carrying out the complex procedures of the method of the invention.

It is apparent that certain automatic features of the apparatus could be controlled manually if desired, and actually, different pieces of apparatus could be utilized for performing each of the individual steps involved in the process rather than incorporating in one apparatus connections which permit for example introduction of a cleaning solution, water and also air.

An object of the present invention is to provide a new and novel method for cleaning hydraulic systems which is particularly useful in cleaning the hydraulic systems of ships such as submarines at the time of installation of the hydraulic system.

Another object is the provision of a method for cleaning hydraulic systems which is adapted to effectively remove substantially all the dirt and foreign contaminants from a complex hydraulic system.

A further object of the invention is to provide a method for cleaning hydraulic systems which is practically fool-proof in operation and which is capable of being carried out by personnel who need not be highly technically trained.

A still further object of the invention is to provide a method of cleaning hydraulic systems which ensures that the system is tight against leaks even at 1½ times normal working pressure and further that the assembled system does not leak.

Other objects and many attendant advantages of the invention will become more apparent when considered in connection with the specification and accompanying drawings, wherein:

FIG. 1 illustrates in a diagrammatic manner a form of apparatus which may be utilized for circulating cleaning solution, water and gas through the hydraulic system to be cleaned; and

FIG. 2 illustrates in a diagrammatic manner a form of apparatus which may be utilized in circulating an acid solution and water through a hydraulic system to be cleaned.

In describing the steps of the method of the invention, it is first assumed that the hydraulic system has been initially assembled in position, and that certain valves and components have been replaced with suitable fixtures as discussed previously, and that it is desired to flush a particular loop of the hydraulic system.

As illustrated in FIG. 1, the hydraulic system loop to be flushed is indicated generally by the reference numeral 10 and includes the piping 11 which may be connected

with various components such as a pump 12, it being understood that this loop may comprise many combinations of components which may occur in the hydraulic systems of ships or the like. Numerals 15 and 16 indicate generally the fittings which are adapted to be connected with suitable fittings of the flushing apparatus by means of flexible connecting lines indicated schematically by reference numerals 17 and 18 and which may for example preferably comprise soft copper tubing and the like.

The flushing rig itself as mentioned previously may assume many varied forms and as illustrated in FIG. 1, the dotted line 20 indicates that portion of the apparatus which might for example be readily mounted upon a portable vehicle such as a small truck for facilitating transport to the desired location.

It will, of course, be understood that the remaining components of the apparatus may also be mounted on such a vehicle, but in many cases the other components will be relatively stationary items which can be connected with the apparatus shown in the dotted line 20 by means of suitable flexible connecting conduit means.

A storage tank indicated generally by reference numeral 25 is adapted to store the cleaning solution, and a heating element 26 is provided at the lower portion of the tank for maintaining the cleaning solution at a desired elevated temperature. The tank is provided with an inlet indicated by reference numeral 28 and an outlet indicated by reference numeral 29. An outlet conduit 30 is connected between the outlet of the tank 25 and a control valve indicated generally by reference numeral 32 shown as being within dotted line 20.

A selectively operable valve 35 is connected in conduit 30 and serves to control the flow of cleaning solution through the outlet conduit. A suitable pump 36 which may be of a high capacity type is also connected in the outlet conduit, a selectively operable valve 37 being provided for controlling the output flow from the pump. A water supply conduit 40 is connected with outlet conduit 30 downstream of pump 36 and may be connected to any source of fresh water which may be available in the vicinity. A selectively operable valve 41 is provided in the water supply conduit 40 for controlling the flow of water into the outlet conduit 30 and a check valve 42 is positioned upstream of valve 41. A fitting indicated generally by reference numeral 43 indicates the position at which the outlet conduit 30 may be interrupted in order to enable the portion of the apparatus shown within line 20 to be movable if desired. A filter 45 is connected in the outlet conduit and may include a filter element adapted to filter out all solid particles larger than 10 microns, for example.

A solenoid operated valve 47 is connected in the outlet conduit downstream of filter 45 and controls the flow of liquid from the filter to the control valve 32, the control valve being a four-way type valve as indicated schematically to permit reversing direction of flow in the loop to be flushed. A check valve 48 is connected in the outlet conduit immediately downstream of the solenoid operated valve 47.

A gas supply conduit 50 is adapted to be connected to any suitable gas under pressure as for example air which in the present case may be at any suitable high pressure. At the present time, a pressure of 80 p.s.i. is being employed since this particular pressure is readily available, but it should be understood that the air could be preferably at a substantially higher pressure if such is available. A fitting 51 indicates where the gas supply conduit may be interrupted for permitting the portion 20 of the apparatus to be separately movable as previously discussed.

A manually operable valve 53 is connected in the gas supply conduit for controlling the flow of gas therethrough. A gas filter 55 is connected in the air supply conduit as is a gas heater 56 for heating the gas such as air to an elevated temperature.

A solenoid operated valve 58 is connected in the gas supply conduit, this valve as well as the previously mentioned solenoid operated valve 47 each being connected to a timer 59. The timer is of a conventional type to intermittently operate the two valves 47 and 58 at selectively timed intervals, the arrangement being such that one valve is open while the other is closed and vice versa. A second check valve 49 is connected in gas supply conduit 50 downstream of solenoid operated valve 58.

A pair of intermediate conduits 60 and 61 are connected with fittings 62 and 63 respectively which are in turn adapted to be connected with flexible conduits 17 and 18 previously discussed. The control valve 32 is adapted to alternately connect intermediate conduits 60 and 61 either with the outlet conduit 30 or with the return conduit 63. A pair of fittings 64 and 65 are shown in the return conduit to permit separation at these points if desired.

A liquid strainer 66 is connected in the return conduit. This strainer may be a duplex strainer having a nylon bag therein of approximately 300 mesh.

A selectively operable valve 70 is connected in the return conduit for controlling the flow of liquid back to the storage tank 25. A conduit 71 is adapted to discharge water from the system, a manually operable valve 72 being provided in this conduit for controlling the flow of water therethrough.

A pump relief conduit 74 is connected between outlet conduit 30 upstream of valve 37 and the return conduit 63 downstream of valve 70. A relief valve 75 is connected in conduit 74 for providing a by-pass relief path for the discharge from pump 36 when solenoid valve 47 is closed during operation of the apparatus.

Referring now to FIG. 2, the apparatus for circulating an acid solution through a hydraulic system is illustrated, the dotted line 80 indicating a portion of the system which may readily be incorporated in a transportable rig. An acid solution tank 81 is provided with an inlet 82 and an outlet 83, the outlet 83 being connected with an outlet conduit 85 which as indicated is adapted to be connected with the fitting 15 of the hydraulic system previously referred to.

A pump 90 is connected in the outlet conduit 85, and a selectively operable valve 91 is connected in the outlet conduit downstream of the pump for controlling the flow of acid solution through the outlet conduit. A pump relief conduit 87 is connected between the outlet conduit 85 upstream of valve 91 and the tank 81, and a relief valve 88 is connected in conduit 87 for providing a pump discharge relief path back to the tank when valve 91 is closed.

A water supply conduit 92 is adapted to be connected to any suitable source of fresh water, and a selectively operable valve 93 is connected in the water supply conduit for controlling the flow of water into the outlet conduit 85 to displace acid from the system upon completion of descaling. A check valve 94 is connected in water supply conduit 92 upstream of the selectively operable valve 93.

A return conduit 95 is adapted to be connected as indicated to the fitting 16 of the hydraulic system previously referred to, and a selectively operable valve 96 is connected in this return conduit for controlling the flow of liquid therethrough. A return strainer 97 is also connected in the return conduit. A water outlet conduit 98 is connected to return conduit 95 and is adapted to vent the water from the system, a selectively operable valve 99 being connected in this conduit for controlling the flow of liquid therethrough.

The initial step of the method is to degrease the hydraulic system by circulating a suitable cleaning solution therethrough. Accordingly, the apparatus as shown in FIG. 1 may be connected with the hydraulic system 10 as indicated. As shown, the control valve is in such a position that the cleaning solution pumped from tank 25 by pump 36 will pass through intermediate conduit 61

and thence through fitting 16 into the hydraulic system and thence back through intermediate conduit 60 and through to return strainer 66 to return conduit 63 from where the liquid will travel back to the cleaning solution tank, it being understood that in this position of operation, valves 35 and 70 are open while valves 41 and 72 are closed, valve 47 also being open while valve 58 is closed. In fact, in this initial step of the invention, the timer 59 may be rendered inactive so that valve 47 will always be open and valve 58 always closed.

Valve 53 is also, of course, open and the solution within tank 25 is maintained at an elevated temperature of approximately 140° F.

The cleaning solution utilized in the present invention may take a number of different forms. There are a number of cleaning agents which are suitable for use in the internal hydraulic system of submarines. For example, the cleaning agents may comprise alkaline cleaners such as sodium hydroxide, sodium carbonates, sodium phosphates, and sodium silicates, these cleaning agents being employed in a water solution wherein the alkaline cleaners are in the range of 1 percent to 10 percent by weight of the solution.

The cleaning agents may also comprise one of a number of different synthetic detergents which serve as wetting agents, these detergents being utilized in a range of approximately 0.1 percent to 1 percent by volume of the water solution. The synthetic detergents may comprise anionic detergents such as sulphated fatty alcohols or alkyl aryl polyether sulphates. The synthetic detergents may also comprise cationic detergents such as tertiary amines or quaternary ammonium compounds. Furthermore, the synthetic detergents may be of the nonionic type such as alkylphenoxy-polyethoxy ethanol or amphoteric amine salt of phosphated polyether alcohols.

When synthetic detergents are used as the cleaning agent, an inhibitor such as sodium bichromate may be added to the solution in a proportion such as two percent by weight of the solution to prevent the formation of aluminum hydroxides. Also, when synthetic detergents are used, it is generally advisable to employ a de-foaming agent to control the foaming action. For example, the de-foaming agents may comprise silicone base de-foamers such as Dow Antifoam B, manufactured by The Dow Chemical Company, Midland, Mich., in the range of 0.003 to 0.03 by volume of the solution.

Another example of a suitable de-foaming agent is pine oil in the range of 0.01 to 0.1 percent by volume of the solution.

In a typical example, the cleaning solution may comprise 0.5 percent Triton X-100 by volume and 2.0 percent sodium bichromate by weight and water solution, one of the de-foaming agents also preferably being employed. This cleaning solution may be circulated through the hydraulic system for a period of approximately one or two hours. Gas slugging may or may not be employed during this initial circulation of cleaning solution through the hydraulic system, it being assumed in the present example that no gas slugging is employed during this step of the method.

The cleaning solution is then displaced from the hydraulic system by closing valve 35 and opening valve 41 of the apparatus shown in FIG. 1 so as to introduce fresh filtered water into the hydraulic system. After the cleaning solution has been returned to the cleaning solution tank valve 70 may be closed and valve 72 opened to permit the fresh water to rinse out the hydraulic system. Valve 41 is then closed while valve 72 remains open to drain the water from the system. The system is then blown dry by opening valve 58 and closing valve 47 so as to introduce heated gas such as air through the hydraulic system.

The apparatus shown on FIG. 1 is then disconnected from the hydraulic system and then an apparatus such as shown in FIG. 2 may be connected with the hydraulic

system for carrying out the scale and flux removal step of the invention by circulating a mild acid solution through the hydraulic system. The acid utilized for scale and flux removal may be of the inorganic or organic type. Typical inorganic acids are sulfuric acid, which may be utilized with a two percent sodium bichromate or other suitable inhibitor, phosphoric acid and sulfamic acid. Suitable organic acids are for example oxalic acid, citric acid and gluconic acid. These acids may be utilized in the range of approximately 1 to 5 percent by volume of a water solution with approximately 1 percent of acid by volume being normally employed. In a typical example, a 1 percent by volume sulphuric acid and 2 percent by weight sodium bichromate and water solution is utilized. This acid solution is not at an elevated temperature and may be relatively cold, the solution being circulated through the hydraulic system for approximately one hour. With the mild acid solution as described above, the acid solution should be circulated through the hydraulic system at velocities of approximately 1 to 4 feet per second. Velocities in excess of 4 feet per second tend to etch the pipe and fittings in the vicinity of weldments. Concentrations of greater than 1 percent of sulfuric acid resulted in zinc plating of the fittings, and the same phenomenon occurred when concentrations of less than 1 percent were circulated for extended periods of time. The mild acid solution described above is suitable for descaling and flux removal in copper and copper-nickel piping. All piping outside of the pressure hull of a submarine is stainless steel. This latter substance requires a slightly different de-scaling procedure than used in copper and copper nickel piping since the acid used on the copper nickel piping would cause stress corrosion in the stainless steel piping. Accordingly, a trisodium phosphate solution of about 2 percent is used in stainless steel piping. The flush procedure is similar to that of the acid flush previously mentioned.

After circulating the scale and flux removal solutions for the time and speed discussed above, the solution is displaced with filtered tap water by turning off valve 91 as shown in FIG. 2 and opening valve 93. The clear water rinse is continued until no residue is left of the de-scaling solution in the piping. Valve 96 can be closed and valve 99 open to complete this rinsing procedure.

The hydraulic system is then subjected to a hydrostatic test at approximately 1½ times its normal operating pressure to ensure that the hydraulic system is tight against leakage.

The apparatus shown in FIG. 2 is disconnected from the hydraulic system and the apparatus shown in FIG. 1 is then again connected with the hydraulic system, and cleaning solution is again circulated through the hydraulic system for particle removal. The cleaning solution may be the same as that employed previously, and it is circulated through the hydraulic system at as high a velocity as can be obtained. A minimum velocity of 5 feet per second is necessary for particle removal and a velocity of 10 feet per second is desired.

While this solution is being circulated at high velocity, air slugging or injection is carried out intermittently. For example, the 80 p.s.i. air may be introduced into the system at 5 second intervals every 20 seconds of operation. This time interval may vary as required and the figures given are typical. Air injection in conjunction with the wetting agent is utilized to produce bubbles which break up the fluid boundary layer in the pipes of the fluid system and utilize surface tension for particle suspension. Large particles which tend to drop out of suspension in full pipe flow are easily carried along in an air bubble.

The direction of flush through the hydraulic system at this stage of the method is alternated at periodic intervals and for example the change of direction of flow may occur at 5 minute intervals. In other words, valve 32 may be turned 90° every 5 minutes to change the direction of

flow of the solution through the hydraulic system. At the same time, timer 59 is actuated at suitable intervals for introducing slugs of air into the system by opening valve 58 and closing valve 47 and alternately closing valve 58 and opening valve 47 for allowing the solution to circulate through the system. It has been found that this bi-directional flush is necessary to remove particles from crevices in the hydraulic system and get them into the flow path. While carrying out this bi-directional flush a nylon bag is inserted in the return strainer 66. The flush is contained in each direction for the desired interval and the nylon bag within the strainer 66 is periodically inspected.

When two clean bags in succession have been obtained, the particular loop or section of the hydraulic system is considered to be clean, and the cleaning solution is displaced from the hydraulic system by turning off valve 35 and opening valve 41 to allow water to enter the system, timer 59 then being rendered inactive so as to leave valve 47 open and close valve 58. The cleaning solution is accordingly displaced back into tank 25, whereupon valve 70 may be closed and valve 72 opened to allow the fresh water to rinse the hydraulic system.

After the system is rinsed, valve 41 may be closed while valve 72 remains open to drain the water out of the hydraulic system. Valve 58 is then actuated to open the valve and valve 53 is also open so as to blow hot air through the hydraulic system. Hot filtered air is blown through the system until a mirror placed under the discharge indicates no moisture present. While blowing hot filtered air through the system all drains are open to remove moisture accumulated at the low points. The apparatus shown in FIG. 1 is then disconnected from the hydraulic system and all openings are capped to ensure against the admission of foreign matter. All valves which have been cleaned in the shop are re-installed and the separately flushed sections of the hydraulic system are connected to one another. At this time extreme care must be taken not to introduce any foreign particles into the hydraulic system.

It is then time to start the oil flush of the hydraulic system. Certain relief valves are installed at this time to protect the system from over pressurization during the oil flush. Jumpers are installed around all operating cylinders and rotating units with the exception of the main system pumps, all relief valves except those specified, hand pumps and tanks. The fixtures previously mentioned may remain installed in place of the control valves and the system at this time is complete with the exception of the various components which are still jumped. 10 micron filter elements may then be installed in the system filters and proper operating fluid introduced into the system which is an oil substance.

A duplex strainer may again be temporarily installed between the return lines and the vent and the supply tank of the oil substance so that one can inspect for dirt removal during the oil flush. The system pumps are used to circulate oil through each flushing loop while checking the nylon bags of the strainer to check for satisfactory freedom from dirt.

The oil is circulated through the hydraulic system in one direction along its normal flow path and in a typical example, the oil flush may continue for a period of approximately 30 minutes to an hour in each flushing loop.

The oil circulated through the hydraulic system during the oil flush is being circulated below its normal operating pressure. Upon completion of the oil flush, air is circulated through the system at its normal working pressure to test the oil tightness of the system to see if any leaks occur.

It is apparent from the foregoing that there is provided a new and novel method and apparatus for cleaning hydraulic systems which is particularly adapted for use in cleaning the hydraulic systems of ships such as

submarines at the time of installation of the systems. The method is such that it effectively removes substantially all dirt and foreign contaminants from the complex hydraulic system and is substantially fool-proof and capable of being carried out by personnel who are not highly technically trained.

The method is such that the system is hydrostatically tested against leaks at 1½ times its normal working pressure and furthermore, the assembled system is tested for oil tightness. The apparatus employed in carrying out the method of the present invention is quite simple and inexpensive and yet is quite efficient and reliable in use and of a compact arrangement.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, and since the scope of the invention is defined by the appended claims, all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents are therefore intended to be embraced by those claims.

We claim:

1. The method of cleaning hydraulic systems comprising degreasing the system by circulating a first non-acid cleaning solution through the system, introducing fresh filtered water into the system to displace the cleaning solution and rinsing out the system, draining said water from the system, blowing the system dry with heated gas, then removing scale and flux by circulating a mild acid solution through the system, then introducing filtered water again into the system to displace said acid solution and rinsing said system, then introducing a second non-acid cleaning solution into the system and circulating said cleaning solution in alternate directions at certain time intervals for producing a bi-directional flush, intermittently introducing injections of gas into the circulating liquid during said bi-directional flush, and further during the bi-directional flush at certain intervals alternately stopping the cleaning solution flow while simultaneously introducing slugs of gas into the system, then again introducing fresh water into the system to displace said last-mentioned cleaning solution, rinsing the system and then draining the water from the system, then again blowing the system dry with heated gas to dry out the whole system, and then circulating an oil solution flush through the system along the normal flow path below the normal operating pressure for residual contamination removal and upon completion of the oil flush, circulating gas through the system at the normal working pressure of the system to test for leaks.

2. The method of cleaning hydraulic systems as defined in claim 1 wherein gas is intermittently introduced into said first non-acid cleaning solution during said degreasing step.

References Cited

UNITED STATES PATENTS

2,196,176	4/1940	Brigham	137—15
2,920,635	1/1960	Wilson	137—15
2,130,417	9/1938	Butzler	137—240
2,770,248	11/1956	Audia	127—240
1,702,702	2/1929	Osborne	134—22
2,222,516	11/1940	Powell et al.	134—22
2,835,234	5/1958	Rasch et al.	134—22
3,180,759	4/1965	Falk	134—22
2,189,950	2/1940	Gump	
2,279,001	4/1942	Matheson et al.	
2,640,724	6/1953	Sanders et al.	

MORRIS O. WOLK, *Primary Examiner*.

ISADOR WEIL, *Examiner*.

J. T. ZATARGA, D. A. ROWE, *Assistant Examiners*.