

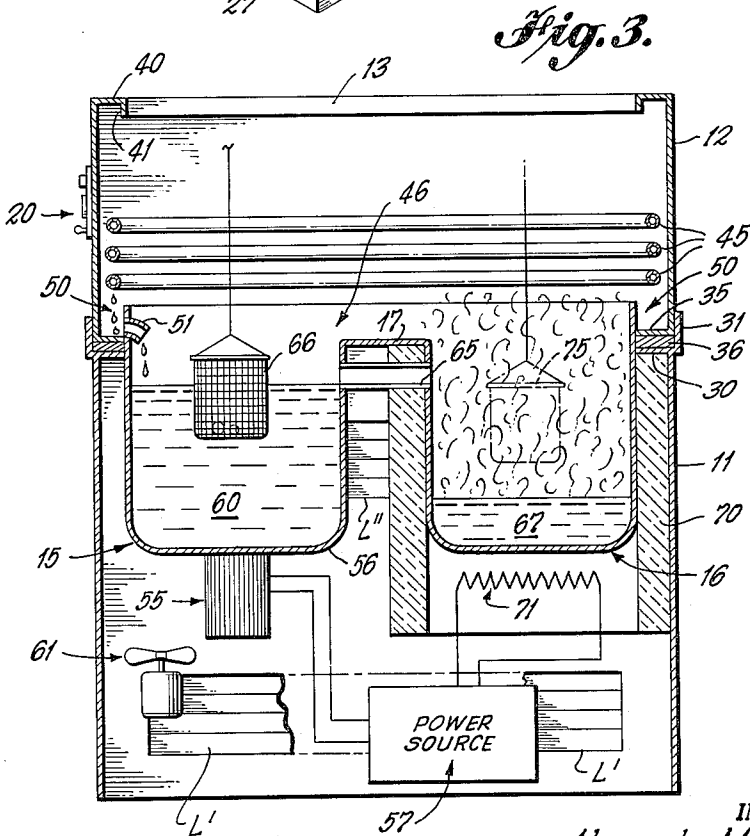
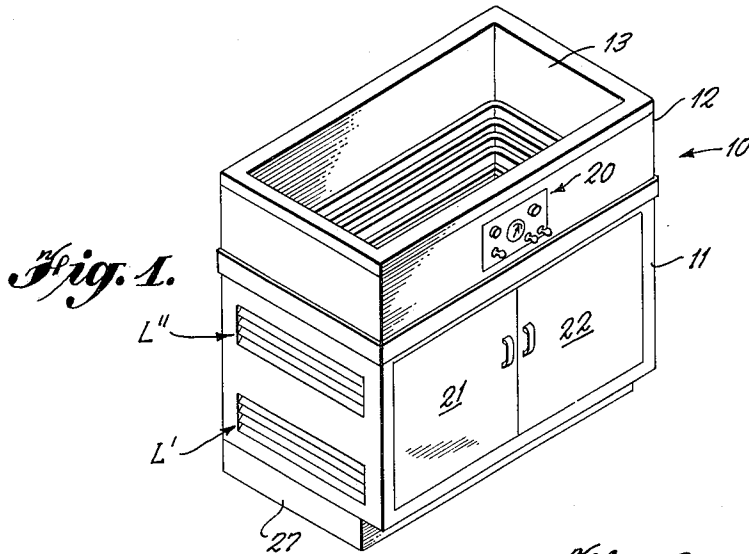
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A. MURDOCH, JR
CLEANING APPARATUS

3,229,702

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2 Sheets-Sheet 1



INVENTOR.

Alexander Murdock, Jr.

BY

Shoemaker and Mattare
ATTORNEYS

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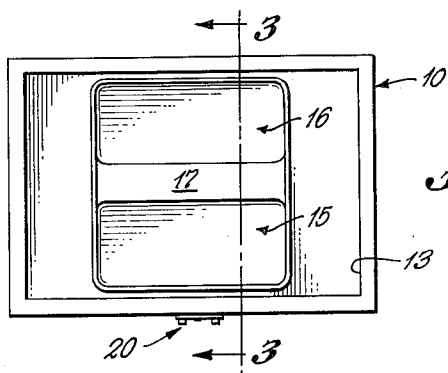


Fig. 2.

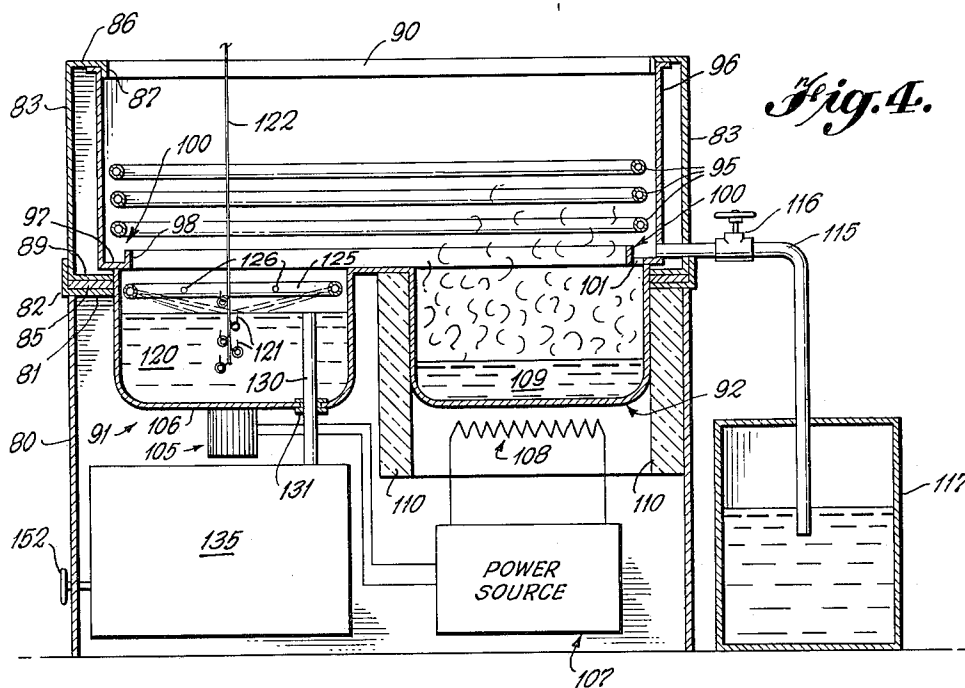


Fig. 4.

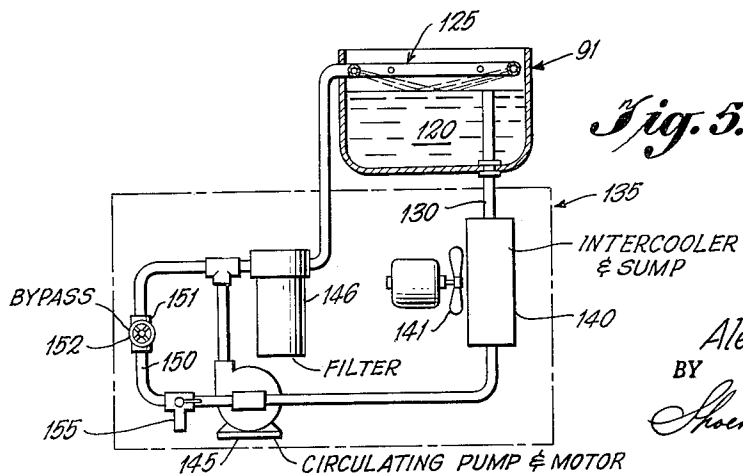


Fig. 5.

INVENTOR.
Alexander Murdoch, Jr.
BY
Shoemaker and Mattare
ATTORNEYS

1

3,229,702

CLEANING APPARATUS

Alexander Murdoch, Jr., Port Washington, N.Y., assignor to Blackstone Corporation, Jamestown, N.Y., a corporation of New York

Continuation of abandoned application Ser. No. 95,073, Mar. 13, 1961. This application Dec. 26, 1963, Ser. No. 339,052

5 Claims. (Cl. 134-89)

The present invention application is a continuation of U.S. Patent application Serial No. 95,073, filed March 13, 1961, now abandoned.

The present invention relates to new and novel cleaning apparatus, and more particularly to apparatus for providing a two-stage cleaning operation.

The cleaning apparatus of the present invention is particularly directed to high precision cleaning operations, wherein it is necessary to attain a high degree of cleanliness. For example, in present day assemblies such as inertial guidance systems, gyro gimbal bearings, high speed servos and the like, extremely close tolerances must be provided. In order to obtain reliability and the low friction required to ensure accuracy, the mechanical parts employed in such systems must be cleaned to an extremely high degree. Prior art cleaning systems which have been entirely satisfactory for coarse bulk cleaning or degreasing are entirely inadequate for performing this type of cleaning operation.

In the present invention, a two stage or multiple stage cleaning operation is provided, the articles to be cleaned being subjected to a first cleaning step wherein insoluble contaminants are removed such as grinding grit, chips, dust and the like, the articles then subsequently being subjected to a second cleaning step which effectively removes soluble contaminants such as grease, oil, waxes, tar and the like.

The type of cleaning medium employed is important, and various cleaning media have been utilized in the art. In the present invention, "Freon" TF 113 or a similar uninhibited compound is employed. "Freon" TF 113 as a cleaning fluid is particularly advantageous since it is neither toxic, inflammable or corrosive. Utilization of this cleaning medium has been quite limited in the past since it is very expensive, and the cleaning medium has been dissipated during the cleaning operation. The cleaning medium of the present invention is accordingly selected from a group consisting of fluorochloromethanes and fluorochloroethanes which are stable, colorless, non-toxic, non-irritating, non-flammable and non-corrosive.

A particular advantage of the present invention in this respect is the fact that means are provided for conserving the cleaning medium and actually continuously reconditioning it such that the same cleaning medium can be used over and over again.

The present invention contemplates two distinct modifications, one of which is simpler and less expensive than the other and which can be used in certain basic cleaning operations. The more sophisticated and complex modification is, of course, more expensive, but is adapted to perform a more efficient cleaning of articles at a much higher production rate than is possible with the simpler modification.

Each of the modifications of the present invention operates on the same general principal and the two modifications incorporate the same general structure. In each case, a pair of cleaning tanks are provided which are preferably spaced closely adjacent to one another within a suitable enclosure, the enclosure being provided with an open top such that the articles to be cleaned can be simply dipped into one tank and then lifted out and dipped into the other tank for cleaning.

2

A common cleaning medium is employed in both tanks, but the cleaning medium is in a different state in each of the two tanks to provide a completely different type of cleaning action. In the first tank, the cleaning medium is maintained below its boiling point such that the cleaning medium is in a liquid state. Operatively connected to this first tank is an ultrasonic transducer means which in cooperation with the liquid in the tank produces a very effective scrubbing and cleaning action due to the creating and collapsing of minute cavities within the cleaning fluid as created by ultrasonic waves projected through the solution. This complex phenomenon called "ultrasonic cavitation" quickly and automatically explodes solid contaminants from the parts to be cleaned. In order to perform this first stage cleaning step, the articles are disposed in submergence in the liquid in the first tank.

In cases where very heavy contamination must be removed, presoak or coarse cleaning methods such as rinses or sprays can be used to advantage before precision cleaning in the described invention is undertaken.

The cleaning medium in the second tank is raised to the boiling point temperature such that a vapor is maintained in the upper portion of the second tank, while a small body of liquid may be provided at the bottom of the tank. The articles to be cleaned are first subjected to the cleaning action of the liquid in the first tank and then are dipped into and suspended within the vapors in the upper portion of the second tank. The coaction of the two tanks is such that the insoluble contaminants are effectively removed in the first tank, while the soluble contaminants are effectively removed in the second tank.

In order to maintain the cleaning medium in the desired physical state in each of the two tanks, a cooling means is associated with the first tank while a heating means is associated with the second tank.

Overflow means is also associated with the first tank so as to limit and control the liquid level of the cleaning solution in the first tank. This is important since the liquid level in the tank is so related to the construction of the ultrasonic transducer associated therewith that the most effective cleaning action is obtained. If the liquid level of the cleaning solution should vary substantially from the desired level, the first cleaning tank will become "untuned" such that the cleaning tank will not operate at its maximum efficiency.

As mentioned previously, means is provided for conserving the expensive cleaning medium. The vapors formed in the second tank may tend to escape from the apparatus by rising above the tank. In order to prevent such vapors from being carried upwardly and outwardly of the apparatus, cooling and condensing means is disposed above and in surrounding relationship to the tanks. This cooling and condensing means preferably takes the form of a cooling coil which serves to cool the rising vapors and cause them to condense and drop downwardly from the cooling coils.

The condensate from the cooling coils is collected in a suitable trough means and then redirected back to one of the tanks. In the first modification, the condensate is redirected back into the first tank, while in the second modification the condensate is redirected back into the second tank. In this latter case, the condensate will continuously replenish the supply of cleaning medium in the second tank so that a vapor can be effectively produced therein. In the first-mentioned simpler modification, the overflow from the first tank into the second tank will serve to replenish the supply of cleaning medium in the second tank.

An object of the present invention is to provide new and novel cleaning apparatus which is adapted to carry out a two-stage cleaning operation.

Another object of the invention is the provision of cleaning apparatus which provides a first stage for removing insoluble contaminants and a second stage for removing soluble contaminants.

A further object of the invention is to provide cleaning apparatus which includes means for controlling the liquid level in the first tank for maintaining peak efficiency operation of the first cleaning tank.

Still another object of the invention is the provision of cleaning apparatus including means for maintaining the cleaning medium in each tank at a desired temperature so as to maintain the cleaning medium in a particular physical state.

A still further object of the invention is to provide cleaning apparatus including means for conserving the cleaning medium.

Yet another object of the invention is the provision of a novel method of cleaning articles in a two-stage cleaning operation.

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 is a perspective view of an enclosure incorporating the cleaning apparatus of the present invention;

FIG. 2 is a top view of the apparatus shown in FIG. 1;

FIG. 3 is a sectional view which is partly schematic taken along line 3—3 of FIG. 2 looking in the direction of the arrows;

FIG. 4 is a sectional view similar to FIG. 3 illustrating a modified form of the invention; and

FIG. 5 illustrates schematically a portion of the apparatus shown in FIG. 4.

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, there is shown in FIGS. 1 and 2 an enclosure indicated generally by reference numeral 10, and including a lower base portion 11 and an upper portion 12, the upper portion 12 having a central opening 13 formed therethrough through which the articles to be cleaned are lowered into and raised from the tanks within the enclosure. As seen particularly in FIG. 2, a pair of tanks indicated generally by reference numerals 15 and 16 are provided, these tanks having their longitudinal dimension extending longitudinally of the enclosure 10, a flat portion 17 extending longitudinally between the two tanks.

As seen especially in FIG. 1, a control panel indicated generally by reference numeral 20 is formed at the central front surface of the top portion 12 and includes suitable electrical switches and indicator means as is conventional for operating this type of equipment. A pair of access doors 21 and 22 are pivotally mounted adjacent opposite edges of the front surface of the bottom portion 11, these doors being adapted to pivot outwardly for gaining access to the interior of the lower portion of the enclosure whenever it is desired to inspect, adjust or repair any of the various components of the apparatus. Each of the end walls of the lower portion 11 of the enclosure, only one of which is visible in FIG. 1, has a lower set of louvers L' and a spaced upper set of louvers L'' formed therein for a purpose hereinafter described. The lower portion of the enclosure is supported upon a suitable support surface by the base portion 27.

Referring now to FIG. 3 of the drawing, it will be seen that lower portion 11 of the enclosure includes an inwardly extending flange 30 formed completely therearound and an upwardly extending flange portion 31 which also extends completely therearound. The side walls of the upper portion 12 of the enclosure include inwardly extending flanges 35 and as seen in FIG. 3, the lower portion of the side wall of the upper portion 12 as well as the flange portion 35 thereof is received within the flange portion 31 of the lower portion and in overlying relationship to the flange portion 30. A heat insulating gasket 36

is disposed between the flange portions 35 and 30 completely around the periphery of the enclosure.

The upper portion 12 includes an inwardly extending rim portion 40 extending completely therearound, the rim portion 40 including a downwardly extending flange 41 defining the central opening 13 previously referred to at the top of the enclosure. Suitably supported adjacent the side walls of the upper portion 12 is a cooling and condensing means in the form of a plurality of cooling coils 45 which extend completely around the upper portion of the enclosure adjacent the inner surfaces of the side walls thereof. Any conventional means may be employed for circulating a cooling fluid through the cooling coils 45 in a well-known manner. The purpose of the cooling coils 45 as mentioned previously is to condense the vapors of the cleaning medium as they rise from the tank and to cause such vapor to condense and to drop downwardly from the coils.

The cleaning tanks 15 and 16 are suitably secured as by welding or the like to the inwardly extending flange 30 of the lower portion 11 of the enclosure, and it will be seen that when the upper and lower portions of the enclosure are in assembled relationship in FIG. 3, the wall portion indicated by reference numeral 46 of the tank structure which extends upwardly above flange portion 35 defines with the lower part of the portion 12 of the enclosure a trough indicated by reference numeral 50 which extends completely around the tank structure. This trough 50 is disposed directly beneath the cooling coils 45 such that condensate dripping downwardly from the cooling coils will be collected in the trough 50. An outlet 51 is provided for directing the collected condensate from the trough 50 into the tank 15 of the apparatus.

Tank 15 is substantially U-shaped in cross-section and an ultrasonic transducer 55 is operatively connected to the lower wall portion 56 of the tank 15. This ultrasonic transducer is preferably of the magnetostrictive type employing a construction as illustrated in U.S. Patent No. 2,874,316, and is adapted to project ultrasonic waves through a liquid cleaning solution within tank 15.

As is illustrated schematically, ultrasonic transducer 55 is connected with a suitable source of electrical energy indicated by reference numeral 57 such that the transducer may be suitably excited when desired.

A body of liquid indicated by reference numeral 60 is provided within tank 15 and comprises the cleaning medium in a liquid form. As mentioned previously, the cleaning medium employed in the present invention is "Freon" TF 113 manufactured by the E. I. du Pont de Nemours Co., this substance having a boiling point of approximately 130° F. This boiling point is particularly suitable for a solvent since it is above the average room temperature at which the apparatus will be operated, and yet the cleaning medium can be easily raised to its boiling point when desired.

In order to ensure that the cleaning medium within tank 15 remains below its boiling point, a fan 61 is provided which will normally be in continuous operation for cooling tank 15.

The fan will draw in outside air through the lower louvers L' and will circulate the air upwardly about tank 15 and then out through the upper louvers L'', and in this manner, the tank 15 will be continuously cooled to maintain the cooling medium therein in a liquid state.

In the present example wherein "Freon" TF 113 is employed having a boiling point of about 113° F., the Freon within tank 15 is preferably maintained at a temperature within the range of about 85° F. to 95° F.

The second tank 16 is of similar construction to the first tank 15 in that it is substantially U-shaped in cross-sectional configuration, and an overflow conduit 65 connects tank 16 with tank 15. Accordingly, when articles to be cleaned are dipped into the body of liquid 60 within tank 15 by means of a small wire mesh basket 66 or a

5

similar container, liquid will overflow through the overflow conduit 65 into the bottom portion of tank 16 and a small body of liquid 67 will thereby be provided in this latter tank. Heat insulating material 70 is provided around tank 16 to retain heat in the walls of this tank for generating a vapor within the upper portion of the tank.

In order to raise the temperature of the heating medium to its boiling point, suitable means such as a heating coil 71 is disposed adjacent the lower wall of the tank, this heating coil 71 in the present instance being shown as connected to the electrical power source 57. Suitable means such as a rheostat or the like (not shown) may be provided for selectively adjusting the temperature of the heating coil 71 such that the body of liquid 67 is heated just enough to maintain a vapor within the tank 16.

The vapors produced in the upper portion of tank 16 above the body of liquid 67 therein is illustrated schematically in FIG. 3, and phantom line 75 illustrates schematically the manner in which the container 66 as shown in submergence in the body of liquid 60 of tank 15 may subsequently be suspended within the vapors in the upper portion of tank 16.

It is apparent that any vapors which rise out of tank 16 will be cooled and condensed by the cooling coils 45 whereby the condensate will be returned through trough 50 to tank 15.

It is therefore evident that during operation, work placed in tank 15 displaces the liquid Freon in an amount depending upon the volume of work. The level of the liquid is thus raised causing the displaced liquid to flow into the rinse tank 16 where it is evaporated. The fresh vapor which is formed and then condensed by the work and the cooling coils is returned to the cleaning tank 15 thereby restoring the liquid level when the work is removed therefrom.

By first placing the work in the cool Freon bath within tank 15, the work is first subjected to an effective scrubbing action that cleans the contaminants out of any minute crevices or blind holes therein. Following this ultrasonic cleaning, a rinse of freshly distilled Freon vapor removes the last trace of soluble contamination which might remain on the work thereby leaving the work bright and clean.

Referring now to FIGS. 4 and 5 of the drawing, a modification is illustrated wherein the lower portion 80 of the enclosure is provided with an inwardly extending flange 81 formed completely around the inner surface thereof, and an upwardly extending flange portion 82 is formed completely therearound. The upper portion 83 of the enclosure shown in FIG. 4 is provided with an inwardly extending flange 84 at the bottom thereof, this inwardly extending flange 84 being disposed in overlying relationship to flange 81 with a heat insulating gasket 85 interposed between the flanges all around the inner surface of the enclosure. An inwardly extending rim 86 is provided at the top of enclosure 83 and a downwardly extending flange 87 defines the central opening 90 through which the articles to be cleaned are manipulated.

Again in this modification, a pair of tanks 91 and 92 are provided, these tanks being similar to the tanks 15 and 16 in the previous modification and being adapted to respectively maintain the common cleaning medium in liquid and vapor states.

A plurality of cooling coils 95 are suitably supported adjacent an inner wall 96 depending from the rim 86 of the top enclosure portion, cooling coils 95 being employed for the same purpose as the coils 45 previously discussed. The depending wall portion 96 extends inwardly at 97 and thence upwardly to define an upstanding wall 98, the walls 96, 97 and 98 cooperating to form a trough 100 completely around the enclosure. It will be noted that trough 100 is disposed directly below heating coils 95 for receiving condensate dripping downwardly from the cooling coils 95 and collecting such condensate there-

6

within. A discharge portion 101 is provided for directing the condensate from trough 100 into the rinse tank 92.

As in the previous modification, an ultrasonic transducer 105 is operatively secured to the lower surface 106 of tank 91, this transducer being connected to a suitable source of electrical energy indicated by reference number 107. Power source 107 is also connected to the heating coil 108 disposed below tank 92 for raising the temperature of a body of liquid 109 within tank 92 to the boiling point of the heating medium so as to maintain the heating medium in a gaseous state in the upper portion of tank 92. As in the previous modification, walls 110 formed of heat insulating material are disposed about tank 92 for retaining the heat within tank 92.

In the modification shown in FIG. 4, a portion of the condensate collected in trough 100 may be tapped off through a conduit 115 through a control valve 116 to a storage tank 117. Storage tank 117 may be employed for storing a portion of the redistilled Freon cleaning medium for reuse whenever desired.

Articles to be cleaned may be suspended in submergence within the body of liquid 120 in the cleaning tank 91 in any suitable manner and as illustrated, a plurality of workpieces are shown supported upon little hook-like members 121 attached to a line 122. It is apparent that many other types of arrangements may be employed for suitably suspending the articles to be cleaned in position within the tank.

As mentioned previously, the combined cleaning action of the body of solvent 120 and the ultrasonic transducer 105 serves to remove insoluble contaminants. Such contaminants may float on the upper surface of the liquid in tank 91 and may cling to the work as it is removed from this tank. In order to dislodge any such contaminants, a pressure spray is provided which will remove any remaining clinging contaminants. This spray is obtained by providing a hollow ring 125 extending within and closely adjacent to the inner periphery of the upper portion of tank 21.

Ring 125 is provided with a plurality of apertures 126 through which cleaning fluid under pressure is emitted to form a fine spray. Apertures 126 are so positioned that the spray will be ejected toward the central portion of tank 91 and thereby will impinge upon the articles to be cleaned as they are lifted out of the body of liquid 120. The means for providing fluid under pressure to ring 125 is hereinafter disclosed.

An overflow pipe 130 projects upwardly through a sealing gasket 131 provided in the lower wall of tank 91 and serves to limit and control the liquid level of the cleaning medium within tank 91. Overflow pipe 130 passes downwardly into an assembly 135 which is illustrated schematically in FIG. 5. As seen in this figure, overflow pipe 130 passes into an intercooler and sump 140. A fan 141 is provided for cooling the intercooler and sump mechanism such that the liquid passing in a closed circuit through the cleaning tank 91 will be maintained below its boiling point.

The output of the intercooler and sump is connected with the input of a continuously operating circulating pump 145, the output of which is connected with a filter 146 which serves to filter out contaminants from the cleaning medium and thereby recondition the medium such that the capacity for contaminant removal is substantially increased.

A bypass conduit 150 is provided for bypassing a certain portion of the output of pump 145 back to the input thereof, the amount of liquid so bypassed being controlled by a valve 151 operated by a hand wheel 152 which may project outwardly of the enclosure as seen in FIG. 4 for readily controlling the amount of liquid which is sprayed through the ring 125. A drain valve 155 is also provided for draining the fluid circulating system as shown in FIG. 5.

In the operation of the apparatus shown in FIGS. 4 and 5, the cleaning tank is first filled with the liquid cleaning solution to the top of the overflow pipe 130, which is of such length that the best working depth of the solution is obtained. An additional amount of Freon is added just until the circulating pump 145 is primed and the filter 146 and the associated piping is filled. This will be indicated by cleaning solution being pumped and sprayed through the ring 125. Under these conditions, the intercooler and sump will be practically empty.

The bypass valve 151 is then opened until the minimum amount of cleaning liquid is sprayed that will rinse the work being processed.

When work is then placed in cleaning tank 91, the liquid Freon will be displaced in a volume equal to the amount of work and will flow into the overflow pipe and be stored in the intercooler and sump 140. Upon removal of the work from tank 91, the liquid level is lowered and the spray emitted from ring 125 will return the level of the liquid within tank 91 to its original depth as determined by the top of the overflow pipe 130. The time lag in restoring such liquid level is negligible since the pump and filter are provided with relatively high capacities.

The heater 108 is regulated such that the Freon in the rinse tank 92 is evaporated at the lowest practical rate thereby preventing the entrainment of oil with the vapor and ensuring maximum vapor purity. Since the vapor is heavier than air, the vapor will permeate the entire volume of tank 92 above the level of the liquid body 109 therein and up to the condenser cooling coils 95.

In certain instances where the articles to be cleaned are particularly dirty, the articles may be subjected to a presoaking in a tank of solvent so as to remove hardened and partially decomposed preservative compounds or greases whereby the apparatus of the present invention is enabled to operate at greater effectiveness.

It is apparent from the foregoing that there is provided new and novel cleaning apparatus particularly adapted for carrying out a two-stage cleaning operation. In the first stage of the cleaning operation, articles to be cleaned are disposed in submergence within a liquid cleaning medium and an ultrasonic transducer is associated therewith for cleaning insoluble contaminants from the articles. The articles are then removed from the first tank and suspended within the vapor in the upper portion of the second tank wherein the temperature of the cleaning medium is raised to its boiling point so as to attain a gaseous state in the upper portion of the second tank. Cooling means is provided in each modification for maintaining the cleaning medium in the first tank in a liquid state, and additionally, heating means is associated with the second tank for maintaining the temperature at least at the boiling point of the cleaning medium. Overflow means is associated with each of the liquid cleaning tanks for controlling the liquid level within the tank to maintain the tank at peak efficiency.

Additionally, each modification incorporates cooling and condensing means for conserving the relatively expensive cleaning medium such that it may be used over and over again during continuous operation of the apparatus.

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.

I claim:

1. Cleaning apparatus comprising first and second cleaning tanks for containing cleaning medium, ultrasonic transducer means operatively connected with said first tank, means for preventing cleaning medium in said first tank from flowing into said second tank including overflow means operatively associated with said first tank for limiting the rise of the level of the cleaning medium therewithin, cooling means operatively connected with said overflow means for controlling the temperature of said cleaning medium in said first tank and maintaining the temperature below the boiling point thereof, means for circulating the liquid overflowing into said overflow means in said first tank, the output of said circulating means being connected with spray means at the upper portion of said first tank, said spray means being so constructed and arranged as to direct a spray of cleaning fluid toward the center of said first tank for removing from articles being cleaned insoluble contaminants dislodged from said articles by ultrasonic action within said first tank, and heating means operatively associated with said second tank for raising the temperature of the heating medium in said second tank to the boiling point thereof to maintain a vapor in the upper portion of said second tank.

2. Apparatus as defined in claim 1, including cooling and condensing means disposed above said tanks for condensing the rising vapors from the tank, and means disposed below said cooling and condensing means for collecting the condensate therefrom.

3. Apparatus as defined in claim 2, including means for directing the condensate from said collecting means into said second tank.

4. Apparatus as defined in claim 1, including filter means connected with the output of said circulating means for filtering out contaminants from the cleaning medium.

5. Apparatus as defined in claim 1, including means for directing condensate from said collecting means to a storage means.

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CHARLES A. WILLMUTH, *Primary Examiner*,
GEORGE J. NORTH, *Examiner*.