March 6, 1962 H. H. SCHLOTT 3,024,138

METHOD OF CLEANING

Filed Sept. 30, 1959 2 Sheets-Sheet 1

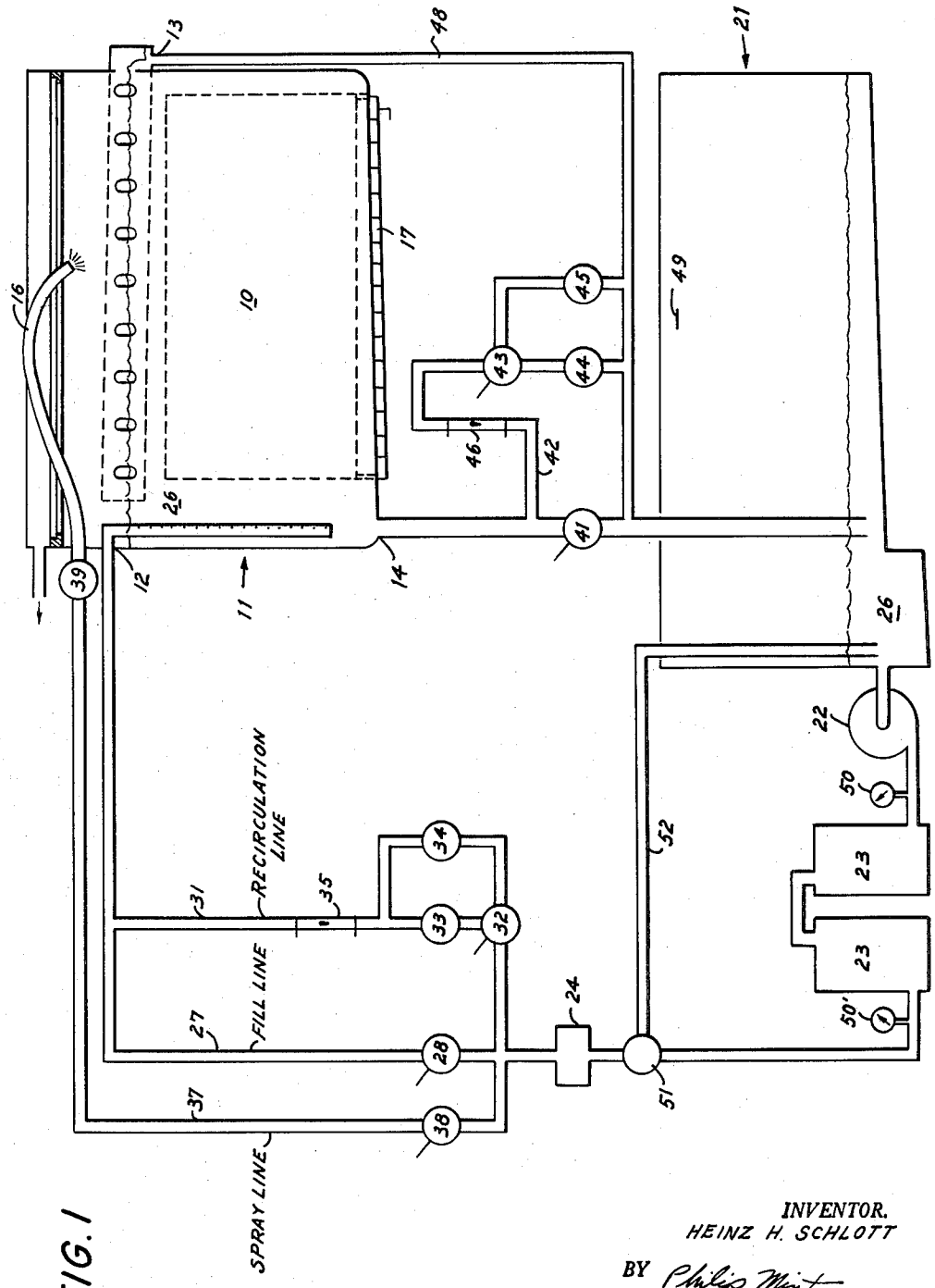


FIG. 1

INVENTOR.
HEINZ H. SCHLOTT
BY Philip Mintz
ATTORNEY

March 6, 1962 H. H. SCHLOTT 3,024,138

METHOD OF CLEANING

Filed Sept. 30, 1959 2 Sheets-Sheet 2

FIG. 2

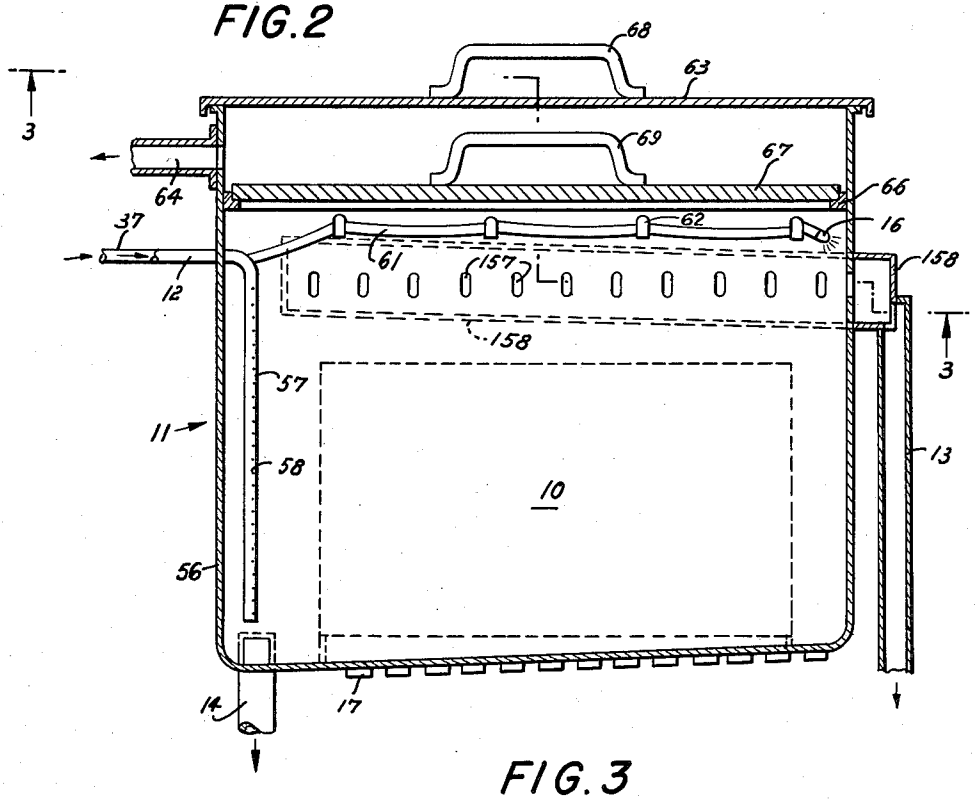
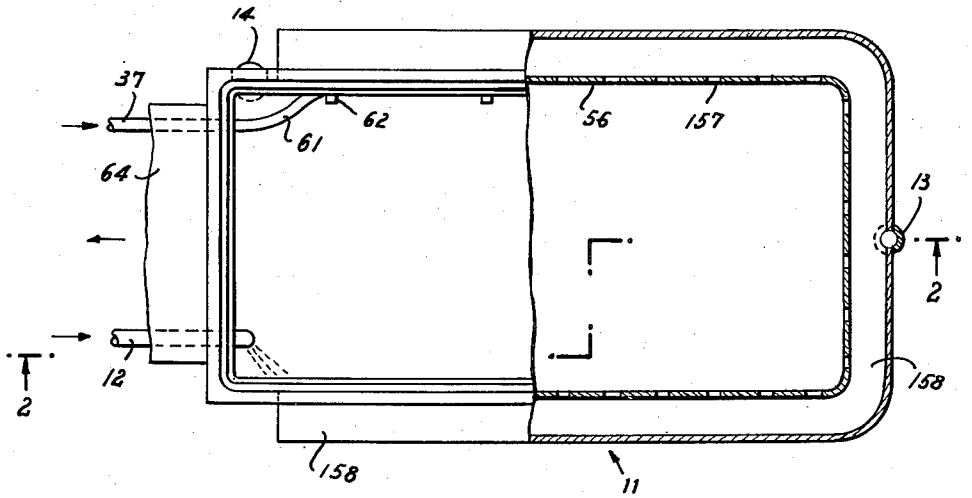


FIG. 3



INVENTOR.
HEINZ H. SCHLOTT

BY Philip Minty

ATTORNEY

United States Patent Office

3,024,138
Patented Mar. 6, 1962

3,024,138

METHOD OF CLEANING

Heinz H. Schlott, Morristown, N.J., assignor to Curtiss-Wright Corporation, a corporation of Delaware

Filed Sept. 30, 1959, Ser. No. 843,564
3 Claims. (Cl. 134—1)

This invention relates to a method of cleaning. More particularly this invention relates to methods of cleaning objects utilizing ultrasonic energy acting through a liquid medium in which the object to be cleaned is immersed.

It has long been known to clean objects by immersing them in agitated baths of strong reagents or other solvents. The washing process, particularly where the objects to be cleaned had crevices or other relatively inaccessible portions was slow and uncertain.

Recently ultrasonic insonation of the cleaning bath has been introduced in an attempt to decrease the time for cleaning objects and to increase the reliability of cleaning dirt, grease, etc. from relatively inaccessible places in the objects, and to remove adhered dirt without the use of strong reagents. This comparatively new method of the use of ultrasonic insonation has provided a great improvement in the techniques of cleaning objects.

While the use of ultrasonic insonation has improved the cleaning process, it has not eliminated all the difficulties present in cleaning operations.

The usual contaminants to be removed from objects to be cleaned may be roughly divided into four types; viz., material which is soluble in the cleaning liquid, material which can float in the cleaning liquid, material which can rapidly sink in the cleaning liquid, and material which can remain in suspension in the cleaning liquid. For ultrasonic cleaning to be really effective all four groups of contaminants must be completely removed from the objects to be cleaned without allowing them to recontaminate the objects.

For cleaning certain types of objects with ultrasonic insonation, volatile solvents may be used as the cleaning liquid. Since all the volatile solvents present either health hazards to human beings or fire and explosion hazards, it is imperative that the apparatus wherein the cleaning operation takes place be so designed as to minimize the escape of volatile solvents into the ambient atmosphere. This has been done by providing exhaust ducts which can rapidly convey the vapors from the volatile solvent to remote locations for dispersal. However, this technique wastes a substantial amount of the volatile organic solvents which are quite expensive.

Accordingly it is an object of this invention to provide cleaning methods which will overcome the disadvantages of the prior cleaning methods and apparatus.

Another object of this invention is to provide ultrasonic cleaning method which will eliminate the recontamination of the object to be cleaned by the contaminants removed from the object during the ultrasonic cleaning cycle.

It is a further object to provide an ultrasonic cleaning method which will rapidly and efficiently clean objects and positively assure complete removal of all contaminants from such objects without permitting the contaminants to settle back on to the objects.

It is a still further object of this invention to provide a container for volatile materials, such as the volatile organic solvents used in the cleaning operation, which prevents vapors from escaping to the surrounding atmosphere and which minimizes the evaporation of such expensive solvents.

With the above objects in view, the present invention mainly consists of a container for containing a cleaning liquid and objects to be cleaned immersed therein. The container is provided with means for continuously introducing cleaning liquid to the container, means for continuously overflowing a portion of the cleaning liquid from the container, and means for continuously draining another portion of the cleaning liquid from substantially adjacent the bottom of the container.

The container may be provided with an outer cover overlying the open upper portion of the container and with an inner cover spaced from the outer cover interposed between the contents of the container and the outer cover. The inner cover forms substantially a gas-tight seal with the container. Means for removing gas from the space between the inner cover and the outer cover is provided.

The invention also consists of the cleaning method which includes subjecting the objects to be cleaned to ultrasonic vibrations while immersed in a cleaning liquid flowing around the objects, then increasing the rate of flow of the cleaning liquid and discontinuing the ultrasonic vibration to flush the objects free of the ultrasonically loosened contamination. The objects are spray rinsed while the cleaning liquid is removed from the zone around the objects being cleaned.

The improved method for cleaning objects immersed in a cleaning liquid contained in a cleaning zone includes continuously introducing fresh cleaning liquid to the cleaning zone, continuously overflowing a portion of the cleaning liquid from the top of the cleaning zone and continuously draining a portion of the cleaning liquid from the bottom of the cleaning zone.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention, itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of a specific embodiment when read in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic flow diagram illustrating the ultrasonic cleaner and associated equipment;

FIGURE 2 is a vertical sectional view of the ultrasonic cleaner taken along line II—II of FIGURE 3; and

FIGURE 3 is a plan view partially in section of the ultrasonic cleaner with the covers removed taken along line III—III of FIGURE 2.

Referring to the drawings, and more particularly to FIGURE 1, there is shown schematically the ultrasonic cleaner container 11 and its associated equipment for continuously recirculating and cleansing the solvent used and for automatically operating according to preselected cleaning cycles. The detailed construction of container 11 will be described later, but for the moment it is sufficient to note that it is provided with a liquid inlet 12, an overflow outlet 13, a bottom drain outlet 14, a sprayer 16, and a plurality of electro-mechanical transducers 17.

The equipment associated with container 11 comprises generally a sump tank 21, a pump 22, filters 23, and associated piping, valves, meters, etc. as will be explained in detail.

From sump tank 21 the liquid 26 passes through pump 22, filters 23, tramp filter 24, and then through one of several alternate paths to the container 11. The alternate paths include (*a*) fill line 27 with automatic valve 28; (*b*) recirculation line 31 with automatic valve 32, alternate manual control valves 33 and 34, and rotameter 35; and (*c*) spray line 37 with automatic valve 38 and manual valve 39. Fill line 27 and recirculation line 31 are both connected to inlet 12 of the container 11; whereas spray line 37 is connected to sprayer 16.

Liquid 26 is returned to sump tank 21 from the container 11 by gravity through several pathways. These

pathways include (*a*) bottom drain outlet 14 and automatic dump valve 41; (*b*) underflow recirculation line 42 with automatic valve 43, alternate manual control valves 44 and 45, and rotameter 46; and (*c*) overflow recirculation line 48.

In a typical and preferred mode of operation, the following sequence of operations is performed in utilizing the above-described system for cleaning objects.

Preliminary to starting the cleaning cycle, sump tank 21 is filled with the liquid cleaning agent 26 to a high level indicated by mark 49. Depending upon the nature of the object to be cleaned and the nature of the substances to be removed from such object, liquid 26 may be a solvent, such as trichlorethylene, for example, or aqueous detergent solutions. The objects to be cleaned 10 (indicated in phantom outline) are placed within the container 11 and may be supported in any suitable manner, such as in racks or in wire mesh baskets, for example.

The liquid 26 is pumped through fill line 27 at high speed to fill the container 11. When the container 11 is full, liquid 26 will commence overflowing through overflow recirculation line 48. At this time automatic valve 28 in fill line 27 closes; automatic valve 32 is positioned to allow flow through manual control valve 34; and automatic valve 43 is positioned to allow flow through manual control valve 45.

Manual control valve 34 is adjusted to give a preselected rate of flow as measured on rotameter 35. Manual control valve 45 is adjusted so as to give a reading on rotameter 46, which reading is a preselected fraction of the reading on rotameter 35. This arrangement gives a continuous circulation of liquid 26 through the entire system, with preselected proportions of the liquid 26 leaving container 11 through overflow 13 and through underflow 14.

Transducers 17, which are connected to an RF generator (not shown) for applying thereto an electrical signal for vibrating the transducers 17 at an ultrasonic frequency, are actuated producing ultrasonic vibrations within liquid 26 in container 11 thereby breaking loose dirt, grease, etc. from the objects to be cleaned which are within container 11. This portion of the cycle is the main ultrasonic cleaning cycle.

After a suitable time for the ultrasonic cleaning cycle the rapid flush circulation is initiated. Automatic valve 32 is shifted to allow inlet flow through manual control valve 33, and automatic valve 43 is shifted to allow outlet flow through manual control valve 44. Manual control valve 33 is adjusted to give an increased rate of flow as measured on rotameter 35. Manual control valve 44 is adjusted to give a preselected flow through rotameter 46, which flow is a specified fraction of the reading on rotameter 35. During this rapid flush circulation, the ultrasonic transducers 17 are turned off and a high rate of recirculation of liquid 26 is maintained thereby washing the dirt, grease, etc. which was broken free during the ultrasonic cleaning cycle away from the objects to be cleaned and through the overflow 13 and the underflow 14.

After a definite time interval for the rapid flow flush cycle, automatic valves 32 and 43 are moved to closed positions and automatic valve 38 in spray line 37 and automatic dump valve 41 are opened. Opening automatic valve 41 allows liquid 26 in container 11 to be dumped rapidly into sump tank 21. Opening automatic valve 38 permits flow of liquid 26 through spray line 37 to sprayer 16. The control of the rate of flow through sprayer 16 is accomplished by manual valve 39. Sprayer 16 is manually moved to allow its spray to sweep over the objects being cleaned during the time the liquid 26 is being dumped from ultrasonic cleaner 11. This spray prevents recontamination of the objects being cleaned due to floating dirt settling out on these objects while the liquid level is being lowered in container 11 during the dumping.

After the dump and spray cycle, auotmatic dump valve 41 and automatic spray valve 38 are closed and the fill cycle is restarted.

The above described operation of automatic valves 28, 32, 38, 41, and 43, and the actuation and turning off of transducers 17 is controlled by means of a conventional time sequence programmer (not illustrated). The automatic valves 28, 32, 38, 41, and 43 may be any of the conventional types of automatically operated valves. Since the specific construction of the valves and the programmer form no part of this invention, no detailed showing of these conventional structures or their conventional interconnection is considered necessary or desirable.

In a typical cycle, the fill cycle takes about one minute; the ultrasonic cleaning cycle takes about 3 minutes with about 1 to 4 gallons per minute flow indicated on rotameter 35; the rapid flow flush cycle takes about 9 minutes with about 6 to 10 gallons per minute indicated on rotameter 35; and the dump and spray cycle takes about 2 minutes with about 6 gallons per minute flow. The sequence of cycles above listed is repeated several times for each cleaning load in order to insure absolute cleanliness for the most critical applications.

During all these cleaning cycles, solid material which is washed from the objects to be cleaned flows out of container 11 through overflow 13 and underflow 14 and is filtered by filters 23. Immediately adjacent filters 23 are pressure gauges 50, 51'. When filters 23 accumulate sufficient solid material to require cleaning, the pressure drop across these filters as measured by pressure gauges 50, 50' will increase to a predetermined value. At such time the filters 23 are cleaned.

When filters 23 are again placed into service, bypass valve 51 is operated so as to allow liquid 26 to be circulated through bypass line 52 for a period of time. This allows any contaminants broken free during filter changes or cleaning to be picked up by the filters before liquid 26 is again allowed to enter ultrasonic cleaner 11.

Filters 23 may comprise any suitable filtering medium such as paper, cloth, or sintered metal filters. As an additional precaution tramp filter 24, which is a sintered metal filter having a very small pore size, is used to prevent solid contaminants from entering container 11.

Referring next to FIGURES 2 and 3, there is shown a detailed illustration of a preferred embodiment of container 11. This mainly includes a tank 56 having mounted thereon a plurality of electro-mechanical transducers 17. Tank 56 is provided with a sloping bottom and with the bottom drain outlet 14 adjacent a lowermost corner of its bottom.

Tank 56 is also provided with the liquid inlet 12 to which is attached a substantially vertical pipe 57. Pipe 57 is located adjacent a corner of the deep end of tank 56. It will be noted that pipe 57 and bottom drain outlet 14 are both adjacent the deepest end of tank 56 but are adjacent opposite corners thereof. Pipe 57 is provided with a plurality of relatively small orifices 58 so positioned as to provide for the liquid 56 flowing therethrough being introduced at approximately a 45° angle to the side of tank 56 remote from bottom drain outlet 14. Therefore, the liquid 56 is introduced substantially tangentially to the inner surface of the side wall adjacent pipe 57. This provides for excellent circulation of liquid 26 within the tank 56.

Also located on tank 56 is the spray line 37 and sprayer 16. Sprayer 16 is connected to spray line 37 by means of flexible hose 61. Flexible hose 61 may be supported along a wall of tank 56 by means of clips 62. For use in the spray cycle, flexible hose 61 is manually removed from clips 62 and sprayer 16 is manually directed at various portions of the objects being cleaned.

Tank 56 is provided with a plurality of orifices 157

extending around substantially all of three of its sides near the upper portion thereof. Attached to the outside of tank **56** surrounding the region of orifices **157**, is a completely enclosed overflow channel **158**. Overflow channel **158** is provided with a sloping bottom surface, and with the overflow outlet **13** adjacent the lowest portion of overflow channel **58**.

It will thus be seen that upon filling tank **56** with liquid **26**, a level of liquid in the tank will be established due to the overflow of excess liquid through orifices **157**. Such overflowing liquid will be caught in completely enclosed overflow channel **158** and then will flow through overflow outlet **13** and thence to sump tank **21**.

Tank **56** is provided with a cover **63** which may be placed upon the top of tank **56** during the cleaning cycle. Immediately below cover **63**, tank **56** is provided with a slotted exhaust outlet **64** adjacent one end thereof which is connected through ducting to an exhaust system (not shown). Immediately below slotted exhaust outlet **64**, tank **56** is provided with an annular machined seat **66** on which an additional heavy lid **67** may be placed.

Cover **63** and heavy lid **67** may be provided with handles **68** and **69** for ease in opening and closing tank **56** whenever desired. Alternatively, cover **63** may be spacedly secured to heavy lid **67** so that they both open and close as a unit for greater ease in handling in the smaller sizes.

The machined seat **66** cooperates with heavy lid **67** to provide a substantially gas-tight seal for the top of tank **56**. When volatile solvents, such as trichlorethylene, are used, heavy lid **67** substantially prevents evaporation of such solvent. What little solvent may evaporate is immediately removed from the working area through slotted exhaust outlet **64**.

This "double-lid" construction with the exhaust outlet between the two lids, greatly reduces the loss of volatile solvents as compared with the losses that would be experienced with a single lid having an exhaust outlet below such single lid. This double lid construction also greatly reduces the losses due to evaporation of solvent as compared with those experienced in using a single loosely fitting lid and an exhaust duct. The use of an exhaust duct eliminates the possibility of producing conditions in the area adjacent the ultrasonic cleaning tank **11** which might be unsafe to personnel working in the area.

It is thus seen that there has been provided a new and improved method and apparatus for use in ultrasonic cleaning which overcomes the disadvantages of prior cleaning methods and apparatus and which ensures positive removal of all contaminants rapidly and efficiently from objects being cleaned and which also minimizes the loss of volatile solvents while keeping the surround atmosphere free of solvent vapors.

While the invention has been illustrated and described as embodied in a certain particular apparatus and its preferred mode of operation, it is not intended to be limited to the details shown, since various modifications and changes may be made without departing in any way from the spirit of the present invention as defined in the claims.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should be and are intended to be comprehended within the meaning and range of equivalents of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A method for cleaning objects which comprises immersing said objects in a flowing cleaning liquid in a cleaning zone; subjecting said objects to ultrasonic vibrations for a definite time interval while immersed in a cleaning liquid flowing around said objects; increasing the rate of flow of said cleaning liquid and discontinuing the ultrasonic vibration to flush said objects free of the ultrasonically loosened contamination; and spray rinsing said objects while draining said cleaning liquid from the cleaning zone.

2. A method for cleaning objects which comprises subjecting said objects to ultrasonic vibrations for a definite time interval while immersed in a cleaning liquid flowing around said objects; increasing the rate of flow of said cleaning liquid and discontinuing the ultrasonic vibration to flush said objects free of the ultrasonically loosened contamination; and spray rinsing said objects while draining said cleaning liquid from the cleaning zone.

3. The process as defined in claim 2 wherein the sequence of steps is repeated several times per cleaning cycle.

References Cited in the file of this patent

UNITED STATES PATENTS

847,495	McKee	Mar. 19, 1907
1,299,698	Fitzgerald	Apr. 8, 1919
1,508,828	Wholey	Sept. 16, 1924
1,545,979	Rosenberg	July 14, 1925
1,988,223	Voss	Jan. 15, 1935
2,342,995	Ballentine	Feb. 29, 1944
2,471,506	Wiswall	May 31, 1949
2,576,236	Paden	Nov. 27, 1951
2,641,270	Allen	June 9, 1953
2,703,093	Boyen	Mar. 1, 1955
2,860,646	Zucker	Nov. 18, 1958

FOREIGN PATENTS

548,960	Great Britain	Oct. 30, 1942