METHOD AND APPARATUS FOR CLEANING OBJECTS WITH SOLVENT

Filed Oct. 12, 1964 3 Sheets-Sheet 1

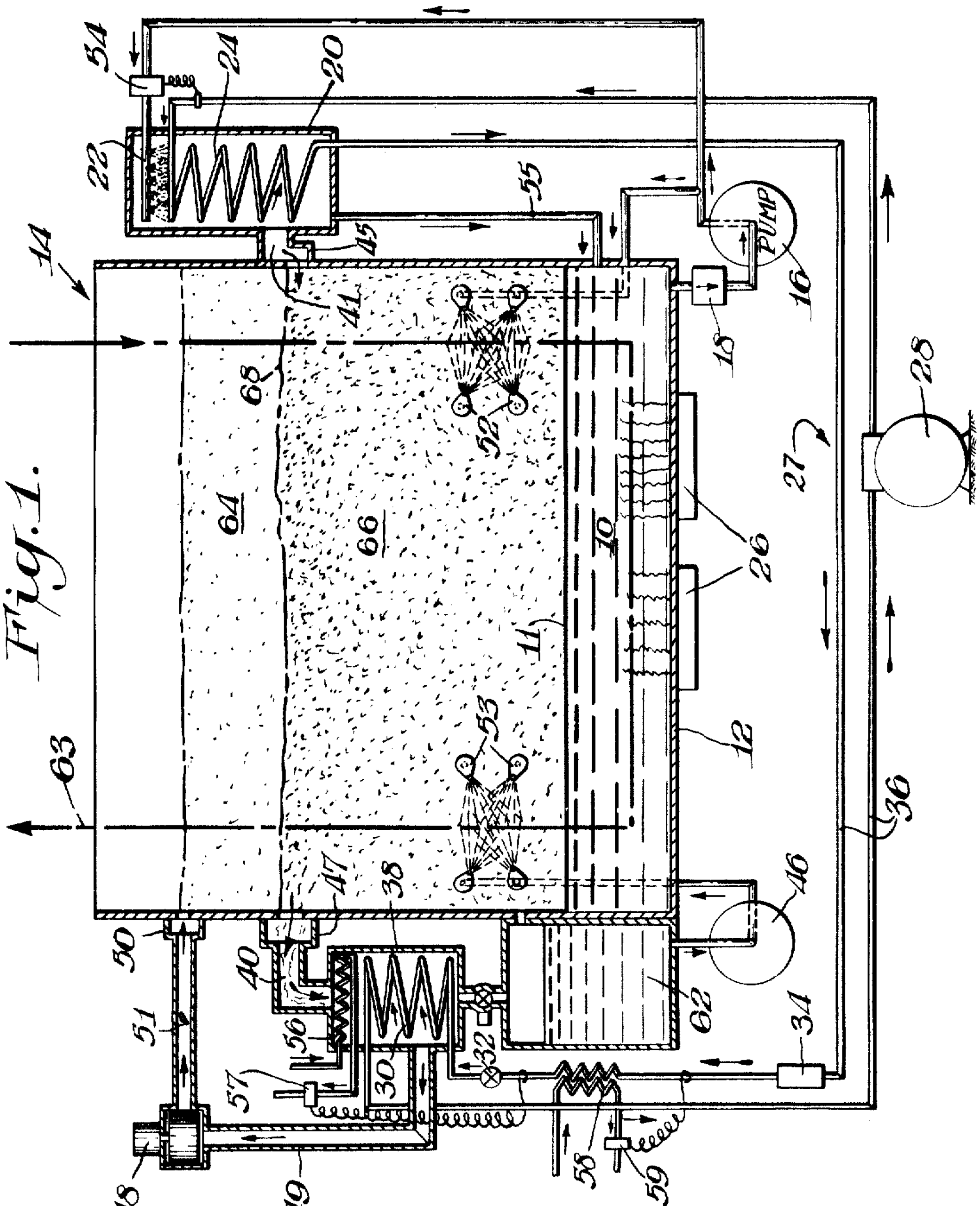


Fig. 1.

INVENTOR
Donald J. Barday
BY Connolly and Hutz
ATTORNEYS

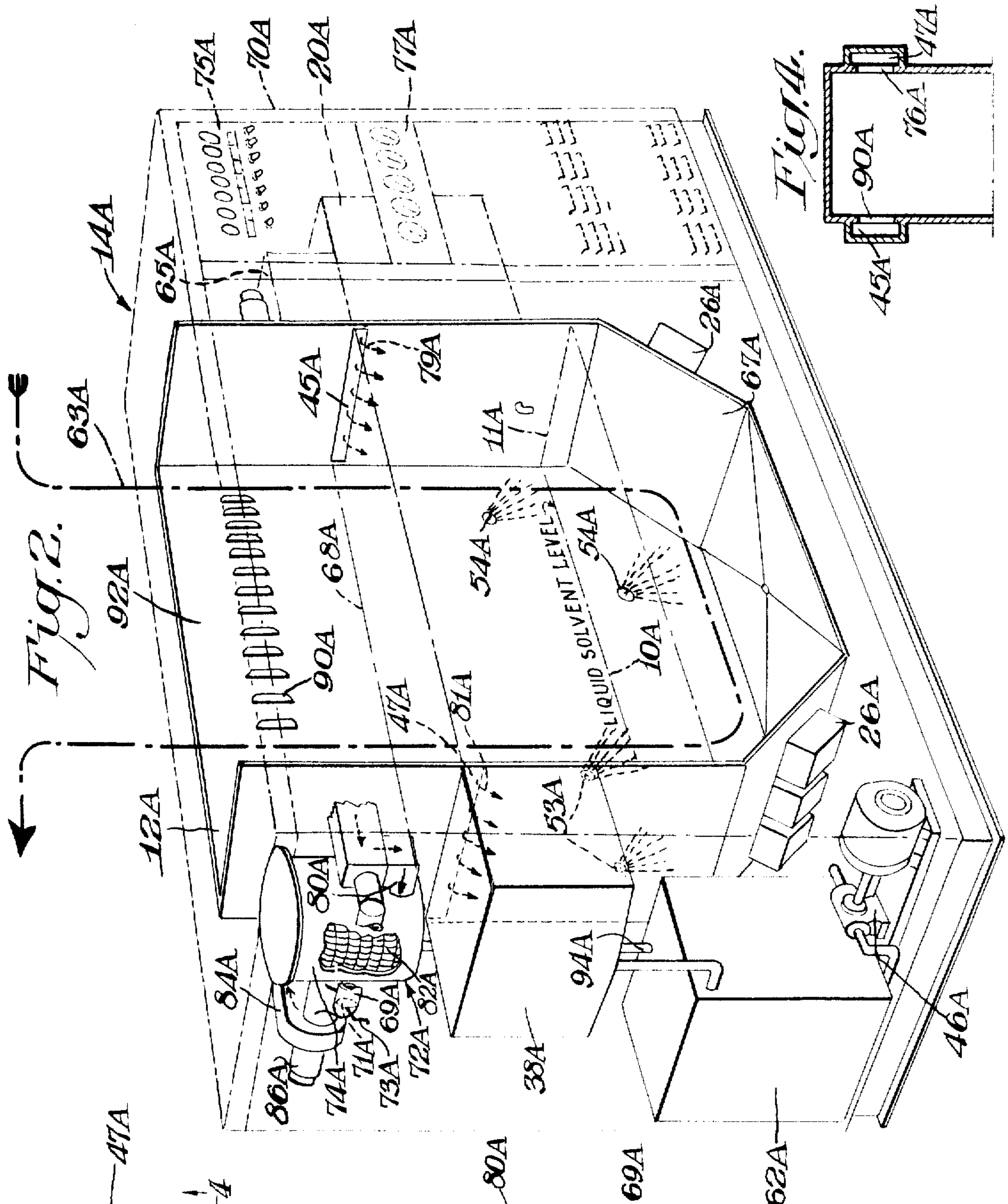


Fig. 2.

Fig. 4.

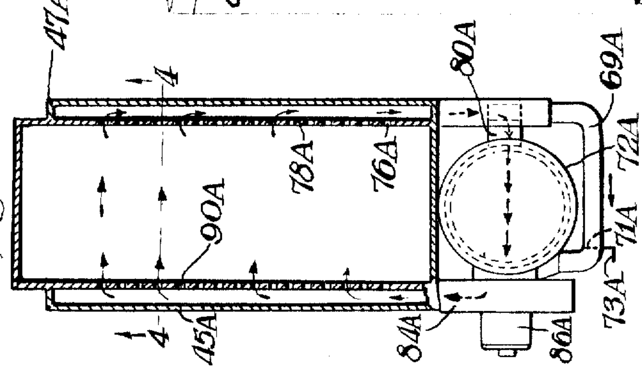


Fig. 3

INVENTOR
Donald J. Barday
BY Connolly and Hutz
ATTORNEYS

March 14, 1967 D. J. BARDAY 3,308,839

METHOD AND APPARATUS FOR CLEANING OBJECTS WITH SOLVENT

Filed Oct. 12, 1964 3 Sheets-Sheet 3

Fig. 5.

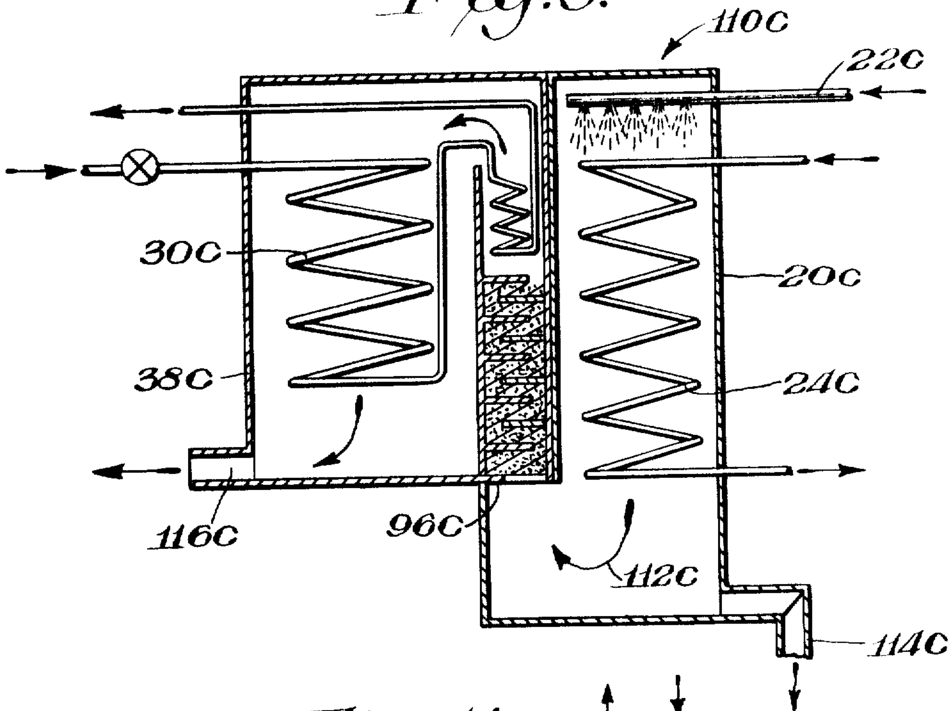
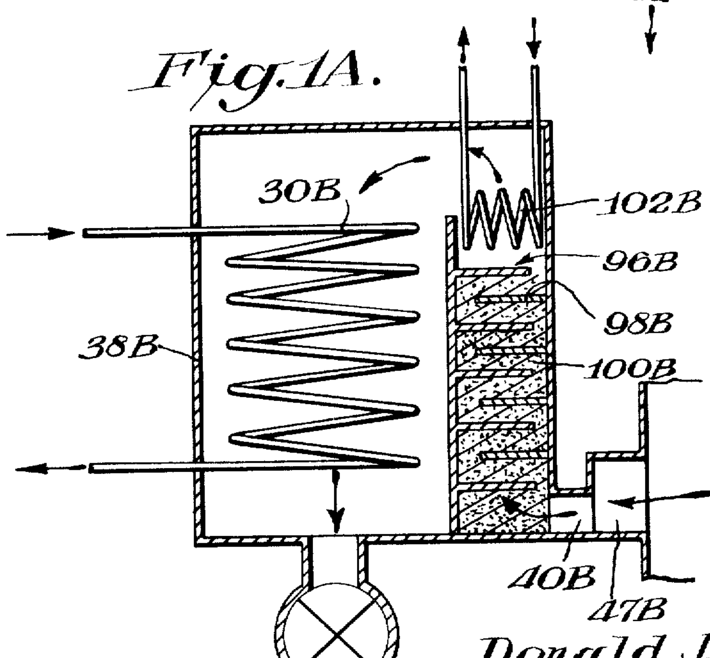


Fig. 1A.



INVENTOR
Donald J. Barday

BY Connolly and Hutz
ATTORNEYS

United States Patent Office

3,308,839
Patented Mar. 14, 1967

1

3,308,839

METHOD AND APPARATUS FOR CLEANING OBJECTS WITH SOLVENT

Donald J. Barday, 721 16th St., Boulder, Colo. 80302

Filed Oct. 12, 1964, Ser. No. 403,142
11 Claims. (Cl. 134—76)

This invention relates to an apparatus for cleaning objects by contacting them with a fluid solvent and, it more particularly relates to a vapor degreasing type of such apparatus.

Pre-existing vapor degreasers drastically heat the liquid solvent in the wash tank to generate a vapor zone above it. This introduces contaminants into the vapor zone and promotes vapor losses, which become significant when more expensive solvents are utilized. This solvent loss is particularly serious with respect to the fluorinated hydrocarbons and the more volatile chlorinated hydrocarbons, which have quite advantageous cleaning properties. They leave little or no residue on cleaned parts upon evaporation and are not injurious to plastics, code markings, electrical insulating materials and the like, but they are relatively expensive. This makes it uneconomical to tolerate the normal losses occurring in industrial cleaning from vapor losses and solvent contamination. Such fluorinated hydrocarbon solvents are trichloromonofluoromethane, trichlorotrifluoroethane, tetrachlorodifluoroethane, or any mixture of them. Such chlorinated hydrocarbon solvents are methyl chloroform, methylene chloride, carbon tetrachloride, or any mixture of them and the fluorinated hydrocarbon solvents. Other advantageous mixtures may contain alcohol or a relatively non-volatile chlorinated hydrocarbon such as trichloroethylene..

An object of this invention is to provide an efficient, simple and economical apparatus for cleaning objects by contacting them with a fluid solvent.

Another object is to provide such apparatus of the vapor degreasing type.

A further object is to provide such apparatus that minimizes solvent losses and makes it possible to economically utilize the efficient, more volatile and expensive cleaning solvents.

In accordance with this invention, vapor zone in a vapor degreaser is maintained by flash evaporating the solvent liquid from a fine spray at temperatures below the normal boiling temperature of a body of the liquid. This minimizes the carryover of contaminants from liquid into the vapor, facilitates dense saturation of the vapor zone and makes it possible to selectively evaporate the more volatile from a mixture of solvents. A more volatile and expensive solvent can thus be mixed with a less volatile and more economical wash solvent and be selectively utilized in the vapor zone and for rinsing in a single chamber unit.

The vapor zone may be effectively maintained by continuously flooding and withdrawing the generated vapor from the area above the liquid. This may be efficiently performed by evaporating a spray of wash solvent upon the heat emitting section of a heat pumping system, and by directing the withdrawn vapor over the heat absorbing section of the same system to condense the liquid from it. This productively utilizes all of the energy in the heat pumping system and provides a supply of pure solvent for rinsing purposes. The heat pumping type of vapor generating, solvent recovering and purifying system is of the type described and claimed in U.S. Patent 3,070,463 by this same inventor.

When a mixture of solvents of differing volatility is utilized, the more volatile component can be selectively evaporated into the vapor. This provides maximum cleaning and rinsing efficiency in the vapor zone with a relatively small amount of more volatile and expensive solvent. Rinsing with relatively cool solvent also cools the objects below the temperature of the saturated vapor zone to condense solvent liquid upon the objects which supplements the rinsing spray.

2

A vapor barrier or blanket of unsaturated air may be maintained directly over the warm saturated vapor zone to isolate it from the ambient atmosphere and to abstract any drops of solvent clinging to the objects. This air blanket may be maintained by continuously withdrawing air and any absorbed vapor from above the warm saturated vapor zone, cooling it to condense any solvent vapor in it and returning the dry air above the vapor zone. In an apparatus open to atmosphere the dry air is returned over it at a temperature cooler than atmosphere to form a dense blanket. The rinsed objects from the vapor zone are thus completely dried in the unsaturated vapor air barrier or blanket before leaving the apparatus and all solvent is retained within the apparatus. Since the temperature of the warm vapor zone is higher than that of the vapor barrier or blanket, the heat absorbed from the vapor zone into the vapor barrier further unsaturates it and improves its drying efficiency. The air withdrawn from above the warm vapor zone may also be advantageously cooled by the heat absorbing section of a heat pumping system and the abstracted condensate utilized for rinsing. The unsaturated vapor barrier may be condensed separately or in conjunction with the saturated vapor zone.

The heat balance of the heat pumping system may be maintained by an auxiliary cooling section for helping condense the vapor because more heat is emitted by a heat pump than is absorbed. The efficiency of condensation of more volatile liquids can be improved by channeling the vapor through a cooled packed reflux column saturated with solvent liquid before contacting the vapor upon the heat absorbing element. The reflux column is maintained saturated by an extra cooling coil mounted above it that drips liquid solvent through it.

Novel features and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

FIG. 1 is a diagrammatic cross-sectional view in elevation of a vapor degreasing apparatus that is one embodiment of this invention;

FIG. 1A is a diagrammatic cross-sectional view in elevation of a modification of the vapor condensing portion of the apparatus shown in FIG. 1;

FIG. 2 is a perspective view partially broken away of a vapor degreasing apparatus that is another embodiment of this invention;

FIG. 3 is a top plan view partially broken away in cross section of the apparatus shown in FIG. 2;

FIG. 4 is a cross-sectional view taken through FIG. 3 along the line 4—4; and

FIG. 5 is a diagrammatic cross-sectional view in elevation of a separately contained solvent purifying and recovering apparatus.

As shown in FIG. 1, pump **16** draws dirty wash solvent **10** from the bottom of tank **12** of vapor degreasing cleaning apparatus **14** through filter **18**. Pump **16** discharges into solvent heating and evaporating chamber **20** by spraying solvent through perforated pipe **22**. Solvent evaporating chamber **20** contains the heat emitting element **24** of a heat pumping system **27** which includes a refrigerant compressor **28** and a heat absorbing element **30**. These elements together with an expansion valve **32** and a refrigerant receiver **34** are connected in a closed heat pumping system by piping **36**. Heat emitting or rejection section **24** is, for example, the refrigerant condensing coil of a heat pumping system **27**; and heat absorbing section **30** is, for example, the refrigerant evaporating coil.

Heat absorbing element **30** is enclosed within a solvent condensing chamber **38**, and a vapor conduit **40** connects solvent condensing chamber **38** to cleaning machine tank **12**. Solvent evaporating chamber **20**, on the opposite side of cleaning machine tank **12**, is connected to tank **12** by conduit **41**. The outlet from conduit **41** and the inlet to conduit **40** are at about the same elevation. This elevation controls the height of the saturated vapor zone **66** in tank **12**.

Vapor produced in solvent evaporating chamber **20** is conducted by conduit **41** into cleaning machine tank **12** by distribution header **45** (laterally extended but not so shown). As saturated vapor in cleaning machine tank **12** rises to the level of vapor collecting header **47** (also laterally extended but not so shown), it spills into collecting header **47** and is conducted by conduit **40** into solvent condensing chamber **38**.

Blower fan **48** induces a flow of saturated vapor into collecting header **47** and, at the same time, induces flow of a vapor-air mixture **64** from above saturated vapor zone **66**. The resultant mixture of saturated vapor and vapor-air mixture is conducted by conduit **40** into solvent condensing chamber **38**. Heat absorbing element **30** converts most of the vapor entering solvent condensing chamber **38** to pure liquid solvent by cooling the vapor to about 35° F. Blower fan **48** draws air, unsaturated with vapor into conduit **49** and discharges a relatively cool mixture thereof into cleaning machine tank **12** through distribution header **50** (also laterally extended but not so shown) at an elevation higher than the saturated vapor zone. A damper **51** in conduit **49** provides a means for fine adjustment of air flow back into tank **12**.

The mixture is cooler than the ambient atmosphere. Thus a relatively cool and relatively dense layer of air and vapor forms a blanket **64** over the saturated vapor **66** in the machine. Blower fan **48** and distribution header **50** are designed to provide a relatively slow exit velocity of air and vapor mixture. This assures its stratification and substantially prevents the intermixing of outside air and the resultant escape of solvent vapor from the top of tank **12**.

Although the air returned to tank **12** through conduit **49** and distribution header **50** is saturated with solvent vapor at about 35° F., the air vapor blanket **64** itself is somewhat above 35° F. or approximately 50° F. to 60° F. Therefore, blanket **64** is not saturated with vapor but is only 60 to 70% saturated. Heat conducted into blanket **64** from the relatively warm vapor zone **66** below, the relatively warm air above and the sides of the cleaning machine account for some temperature increase and a corresponding reduction in saturation value or relative humidity. Since blanket **64** is not saturated with solvent vapor, warm parts emerging from the machine and passing through it dry promptly by evaporation of liquid from their surface.

Three factors contribute to rapid drying of parts in the air-vapor barrier zone **64**. (1) Parts passing through the saturated vapor zone **66**, below, are warmed by vapor condensing on the part in final rinse operation; (2) the air-vapor blanket is not saturated with solvent vapor and has the capacity to absorb additional vapor; and (3) the vapor rinse solvent is relatively volatile and has a characteristically high evaporation rate.

Solvent system cycle of operation of FIG. 1

Compressor **28** and pumps **16** and **46** are started. Blower fan **48** is started. Pump **46** withdraws pure reclaimed solvent from storage tank **62** and forces the liquid through rinse spray nozzles **53**. Cleaning machine tank **12** may either be empty or may contain an operating charge of relatively non-volatile wash solvent. In the first case, where a homogeneous precision solvent is used alone, liquid discharged from spray nozzles **53** enters the inlet to pump **16** as this liquid falls to the bottom of tank **12**.

In the second case, liquid is immediately available to pump **16**.

Pump **16** supplies both the wash spray nozzles **52** and perforated pipe **22** within solvent evaporating chamber **20**.

As pumps **46** and **16** force liquid solvent through spray nozzles **53** and **52** respectively, some of the liquid evaporates in chamber **20** and fills cleaning machine tank **12** with vapor up to the saturated vapor line **68**. Thereafter, vapor enters collecting header **47** and is conducted by conduit **40** to heat absorbing element **30**.

Heat taken up by heat absorbing element **30** in the process of condensing this vapor to liquid, is promptly transferred to heat emitting element **24** by the refrigerant pumped by compressor **28**. As discharge pressure of compressor **28** increases, a pressure-operated, modulating solvent control valve **54** admits liquid solvent to perforated pipe **22**.

The liquid solvent is distributed uniformly over heat rejecting element **24** and it cascades downward in a thin film to wet the entire surface of the heat rejecting element **24**. The more volatile precision solvent component such as trichlorotrifluoroethane, easily flash evaporates from a mixture containing it, and the resultant vapor enters cleaning machine tank **12** through conduit **41** and distribution header **45**. Less volatile solvent components, such as trichloroethylene, and soluble contaminants, such as oil, grease, flux, resins and the like, are returned to tank **12** as liquid through drain line **55**.

Solvent control valve **54** admits liquid solvent to distribution header **22** and heat emitting element **24** in precisely the proper amount to maintain a constant surface temperature of heat rejecting element **24**. Flow valve **54** can be adjusted to maintain any heat rejecting temperature within the range of 75° F. to 150° F. and possibly higher. Therefore, the heat emitting temperature can be precisely controlled to cause evaporation of a precision solvent component while less volatile components and contaminants are returned to cleaning machine tank **12** as liquid. Consequently, vapor in the machine tank **12** and vapor entering solvent condensing chamber **38** is substantially pure, homogeneous solvent of the precision cleaning type. Flash evaporation without liquid boiling eliminates entrainment of contaminated liquid droplets in the vapor.

Since a heat pumping system rejects more heat than it absorbs (in the amount of heat equivalent of electrical energy supplied to the compressor drive motor) it is inherently thermally unbalanced. Heat dissipated through conduction, convection and radiation from machine tank **12** tends to rebalance it thermally. An auxiliary water-cooled heat absorbing element **56** is also located in the upper part of solvent condensing chamber **38** to intercept and condense some of the solvent vapor entering chamber **38**. Heat absorbed by element **56** is transferred to the cooling water and is removed from the system to positively maintain its thermal equilibrium. Furthermore, energy supplied to the compressor motor is utilized to evaporate more solvent than otherwise would be produced by transferral of heat from heat absorbing element **30** to heat rejecting element **24**.

A pressure-operated, modulating flow control valve **57** admits precisely the proper amount of water to auxiliary heat absorbing element **56** to maintain thermal equilibrium conditions at all times. Flow control valve **57** senses discharge pressure of compressor **28** and admits cooling water to auxiliary heat absorbing element **56** only when the temperature of heat rejecting element **24** tends to rise above the predetermined operating temperature and the discharge pressure of compressor **28** tends to rise above the predetermined operating pressure.

A third auxiliary or supplemental heat absorbing element **58** is in a heat transfer relationship with refrigerant piping **36**. Supplemental heat absorbing element **58** subcools liquid refrigerant before it is expanded within heat absorbing element **30**. Heat absorbing element **58** may also function as an auxiliary refrigerant condenser during periods when precision solvent is being recovered for storage in reservoir **62**, particularly toward the end of the recovery cycle. Heat absorbing element **58** may also function as an auxiliary refrigerant condenser during periods when the cleaning machine is not in use and full recovery of precision solvent is not desired. Water flow control valve **59** admits water to heat absorbing element **58** only when auxiliary cooling of refrigerant is necessary. While cleaning operation is suspended, precision solvent remains in tank **12** and the heat pumping system operates periodicaly to maintain the cool air blanket and prevent the loss of solvent vapor. Automatic operation is easily attained by the use of temperature operated and pressure operated controls of conventional type.

The selective vapor generating aspects of this provide a simple and economical method of using a mixture of a relatively expensive precision cleaning solvent, such as trichlorotrifluoroethane, and a relatively inexpensive solvent, such as trichloroethylene. Such selective flash evaporation also makes it possible to utilize an azeotropic mixture for wash purpose and a substantially homogeneous precision solvent for rinse purpose. For example, an excess of trichlorotrifluoroethane can be added to an azeotropic mixture of trichlorotrifluoroethane and methylene chloride or to an azeotropic mixture of trichlorotrifluoroethane and ethyl alcohol. Vapor in the machine and vapor condensed to liquid is substantially pure trichlorotrifluoroethane while wash liquid in the machine has the composition of the azeotrope. The parts are rapidly dried in the unsaturated air-vapor zone before they leave the machine thus eliminating solvent loss by evaporation of solvent from parts outside the machine. All of the volatile solvent is thus purified and reclaimed for repeated use. Heat-sensitive solvents, such as methyl chloroform, may also be efficiently used in a vapor degreasing operation without the danger of solvent decomposition. The low temperature vapor zone also contributes to the overall efficiency of operation, purity of vapor and avoidance of undue solvent losses.

Cleaning cycle of operation of FIG. 1

The cleaning cycle with respect to parts or assemblies moving through the apparatus shown in FIG. 1 is as follows:

A conveyor or other means, not shown, lowers parts into cleaning machine tank **12** along the right-hand side of the tank along path **63** as shown in FIG. 1. Parts pass through the cool air-vapor blanket **64** then into the saturated vapor zone **66** and between the wash spray nozzles **52**.

The parts or objects then enter the immersion wash bath **10** at the bottom of tank **12** near the ultrasonic transducers **26** and are exposed to ultrasonically agitated liquid solvent to remove adherent soils. The parts continue through the immersion wash solvent **10** to the left-hand side of the tank shown in FIG. 1 where they emerge from wash solvent **10** and pass through a pure liquid spray rinse from spray nozzles **53** in saturated vapor zone **66**. The rinse solvent discharged through nozzles **53** is relatively cool and, consequently, the parts being cleaned are cooled to a temperature well below the temperature of the vapor in the saturated vapor zone **66**. The cooled parts are then within the saturated vapor zone and pure vapor promptly condenses on them to help rinse them with precision cleaning solvent.

As the parts leave saturated vapor zone **66**, they are warmed up to approximately its temperature and wet with liquid solvent. As these parts pass through the relatively cooler and unsaturated air-vapor blanket zone, a combination of effects causes all liquid to evaporate from them. The vapor so evolved is retained in the cleaning apparatus system as condensed rinsing solvent as the dry, clean parts pass out of the apparatus.

In FIG. 2 is shown a modified version **14A** of vapor

degreaser **14**. It includes tank **12A** similar to tank **12** which is enclosed on sides and bottom by casing **70A** shown in phantom but open on the top. The near side of tank **12A** is removed to facilitate illustration of its interior. Wash and rinse sprays **52A** and **53A** are disposed in wall **92A** and **78A** (removed in FIG. 2). All portions not specifically mentioned herein are similar to those in apparatus **14**.

The principal difference in apparatus **14A** from **14** is separate vapor condensing system **72A** for unsaturated air-vapor zone **64A**. Zones **64A** and **66A** are not shown and are similar to **64** and **66**. As shown in FIGS. 2–4, vapor condensing system **72A** includes a cooling chamber **74A** through which the air-vapor mixture from unsaturated barrier zone **64A** is passed. The air-vapor mixture is withdrawn through a set of slots **76A** (shown in FIG. 3) in the side of wall **78A** (removed in FIG. 2). The mixture accordingly enters abstracting header **47A** and is conducted therefrom into condensing chamber **72A** through duct **80A**. The mixture is cooled by contact with cooling coils **82A** and then passed through pump or fan **84A** driven by motor **86A** into return header **45A**. Slots **90A** in wall **92A** feed the dried and cool air-vapor mixture in an unsaturated condition to unsaturated vapor barrier or blanket zone **64A**. The heat from saturated vapor zone **66A** below it and the ambient heat raises the temperature of barrier zone **64A** to further unsaturate it and improve its drying ability. The air blanket is accordingly maintained through a separate abstracting, cooling and return system over the saturated vapor zone **66A** the same as shown in FIG. 1. Cooling coils **82A** may be part of a heating pumping system similar to that described in conjunction with FIG. 1, but it also might be a separately cooled system such as by water circulation. The condensate from condensing chamber **72A** passes through pipe **94A** into liquid solvent storage tank **62A**.

Ultrasonic generator **65A** powers transducers **26A** in the sloped bottom wall **67A** of tank **12A** that sheds solid soil. Bypass duct **69A** around blanket zone condenser **72A** controls the temperature of the air-vapor mixture returned to zone **64A** above saturated vapor upper limit **68A** in conjunction with butterfly valve **71A** and control handles **73A**. Apparatus **14A** is controlled from panel **75A** in conjunction with instrument panel **77A**. Saturated vapor is fed into tank **12A** through header **45A** as shown by arrows **79A**, and the overflow is withdrawn through header **47A** as shown by arrows **81A**. The liquid solvent level is shown by the line **11A**.

In FIG. 1A is shown a modification of solvent condensing chamber **38B** in which a reflux column **96B** is interposed in the path of vapor collected by header **47B** and conducted through duct **40B**. Reflux column **96B** includes a series of baffles **98B** between which packing **100B** having extended surface such as wool is packed. Baffles **98B** are effectively made of stainless steel. Column **96B** is maintained saturated with solvent liquid by dripping it down upon it from an extra cooling coil **102B** mounted above it. This cooling coil may be cooled by water circulation or by heat absorbing section of a heat pump. Reflux column **96B** enriches the vapor before it contacts condensing coil **30B** to improve the overall efficiency of condensation. This is particularly true where a more volatile cleaning solvent is utilized.

FIG. 5 shows a separately contained solvent purifying and recovering apparatus **110C** of the type described and claimed in U.S. Patent 3,070,463 by this same inventor. It includes a solvent evaporating chamber **20C** and a solvent condensing chamber **38C** between which reflux column **96C** is mounted. Unit **110C** can be used to purify the main body of wash solvent **10** of apparatus **14** when it becomes loaded with contaminants. Solvent **10** is sprayed through pipe **22C** of heat emitting coils **24C** and vapor is flash evaporated to pass in the direction of arrow **112 C** toward reflux column **96C**. Excess solvent not evaporated is returned to tank **12** through drain connection **114C**. The vapor is enriched in reflux column **96C** in the manner previously described and ultimately condensed by heat absorbing coil **30C** which is advantageously part of a heat pumping system that also includes heat emitting coil **20C**. The purified solvent is returned to tank **10** through outlet **116C**.

What is claimed is:

1. An apparatus for cleaning objects by contacting them with a solvent liquid comprising a tank for containing said liquid and its vapor, vapor generating means connected to said tank for establishing and maintaining a warm saturated vapor zone above the level of said liquid, first vapor abstracting means connected to said tank a distance above said liquid level for limiting the upper level of said warm saturated vapor zone, second means for abstracting the mixture of air and solvent vapor disposed within said tank above said saturated vapor zone and said first vapor abstracting means, means for drying said abstracted mixture and returning it above said warm saturated vapor zone to provide a cool unsaturated air blanket above it to shield said warm saturated vapor zone from the ambient atmosphere, the portion of said tank between said warm saturated vapor zone and said blanket being free of any means preventing said blanket from directly contacting said warm saturated vapor zone, and conveyor means for moving said objects from said liquid where they are washed through said warm saturated vapor zone where they are rinsed and through said blanket where they are dried.

2. An apparatus as set forth in claim **1** wherein rinse spray means is disposed within said tank within said warm saturated vapor zone in the path of movement of said object.

3. An apparatus as set forth in claim **1** wherein said drying means comprises cooling means for condensing said vapor and cooling said air below the temperature of the ambient atmosphere to blanket said warm saturated vapor zone from said ambient atmosphere.

4. An apparatus as set forth in claim **1** wherein said vapor generating and first vapor abstracting means are respectively comprised by the heat emitting and heat absorbing sections of a heat pumping system whereby the energy in said system is completely utilized, and said heat absorbing action being adjusted to condense said vapor.

5. An apparatus as set forth in claim **4** wherein said vapor generating means comprises spray means for discharging a fine spray of said solvent liquid upon said heat emitting section of said heat pump whereby said vapor is flash evaporated from said liquid at a relatively low temperature.

6. An apparatus as set forth in claim **5** wherein an auxiliary cooling section is mounted adjacent said heat absorbing section of said heat pumping system for maintaining said system thermally balanced.

7. An apparatus as set forth in claim **4** wherein a pure liquid solvent reservoir is provided, a connection from said first vapor abstracting means to said reservoir for draining said liquid condensed in said first vapor abstracting means to said reservoir, pumping means connected

to draw from said reservoir, rinse spray means mounted in said tank within said warm saturated vapor zone, said pump being connected to supply said rinse spray means with relatively cool solvent whereby the temperature of said objects in said rinse spray is lowered whereby additional vapor is condensed upon said objects from said warm saturated vapor zone for helping rinse them.

8. An apparatus as set forth in claim **7**, wherein a wash solvent pumping means is connected to said tank for drawing said liquid solvent from it, wash spray means in said warm saturated vapor zone, piping connecting said wash solvent pumping means to said wash spray means and to evaporating spray means for discharging it in heat exchange relationship with said heat emitting section of said heat pumping system, and drain means from said heat emitting section to said tank for returning excess unevaporated solvent to it.

9. An apparatus as set forth in claim **7** wherein a reflux column is disposed in front of said heat absorbing section of said heat pump, solvent liquid supplying means being disposed at the top of said column for dripping liquid solvent through said column, vapor conducting means for passing said vapor through said column into said heat absorbing section, and packing means in said column for collecting and holding said liquid dripped through it from said auxiliary cooling means to enrich said vapor directed into said heat absorbing section and to improve liquid recovery from said vapor.

10. An apparatus as set forth in claim **1** wherein said first and second abstracting means for said warm saturated vapor and cool unsaturated mixture of air and vapor above said warm saturated vapor zone comprise a single abstracting means disposed at said upper level of said warm saturated vapor zone.

11. An apparatus as set forth in claim **1** wherein said first abstracting means for said warm saturated vapor zone is disposed adjacent the upper level of said warm saturated vapor zone and said second abstracting means for said cool mixture of air and vapor above said saturated vapor zone is disposed a substantial distance above said upper level of said warm saturated vapor zone for effectively defining the upper level of said air blanket.

References Cited by the Examiner

UNITED STATES PATENTS

1,892,652	12/1932	Heath	203—87 X
2,220,125	11/1940	Seaton	134—11
2,265,762	12/1941	McKittrick et al.	203—100 X
2,755,208	7/1956	Kearney	134—11
2,896,640	7/1959	Randall et al.	134—11 X
2,949,119	8/1960	Smith	134—76 X
3,030,913	4/1962	Arnold et al.	134—11 X
3,070,463	12/1962	Barday	134—11
3,074,417	1/1963	Lisowski et al.	134—76
3,106,927	10/1963	Madwed	134—76
3,106,928	10/1963	Rand	134—79

CHARLES A. WILLMUTH, *Primray Examiner.*

R. L. BLEUTGE, *Assistant Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,308,839 March 14, 1967

Donald J. Barday

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, lines 2 and 3, and in the drawings, sheets 1 to 3, for "METHOD AND APPARATUS FOR CLEANING OBJECTS WITH SOLVENT" read -- APPARATUS FOR CLEANING OBJECTS WITH SOLVENT --; column 1, line 39, after "such" insert -- an --.

Signed and sealed this 7th day of November 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents