

[54] **VAPOR DEGREASER PROCESS
EMPLOYING
TRICHLOROTRIFLUOROETHANE AND
ETHANOL**

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[58] Field of Search **134/11, 12, 31, 40, 105, 134/109; 252/364; 202/170 D**

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[57] **ABSTRACT**

Articles are cleaned in a vapor degreaser open to the

atmosphere utilizing mixtures of 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol as the boil sump liquid; the concentration of ethanol exceeding its azeotropic value. The vapors of the boil sump liquid are maintained in a nonflammable condition by:

- a. employing a boil sump liquid consisting essentially of 35–85 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 15–65 weight percent of ethanol;
- b. employing a rinse sump liquid consisting essentially of 88–100 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 0–12 weight percent of ethanol;
- c. adding to maintain the liquid volume of the system a make-up liquid mixture consisting essentially of 90–97 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 3–10 weight percent of ethanol in such amount that the volume of the boil sump liquid is at least the volume calculated from the equation

$$v_m v_i / 100 [(1.44 c_b + 2.30 c_r 22.1)]$$

wherein

v_m —minimum permissible volume of boil sump liquid,

v_i —initial volume of boil sump liquid,

c_b —initial weight percent concentration of ethanol in the boil sump liquid and

c_r —initial weight percent concentration of ethanol in the rinse sump liquid; and

- d. maintaining the liquid volume in the rinse sump and condensate diverting means at least equal to the initial liquid volume in the boil sump.

2 Claims, 3 Drawing Figures

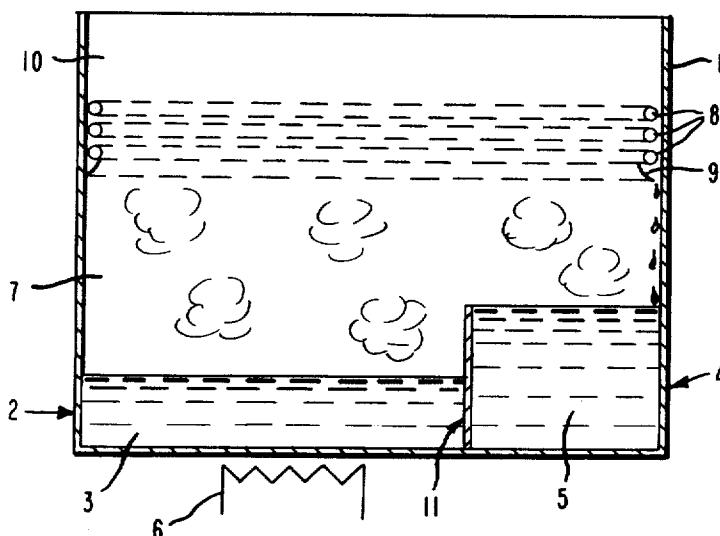


FIG. 1

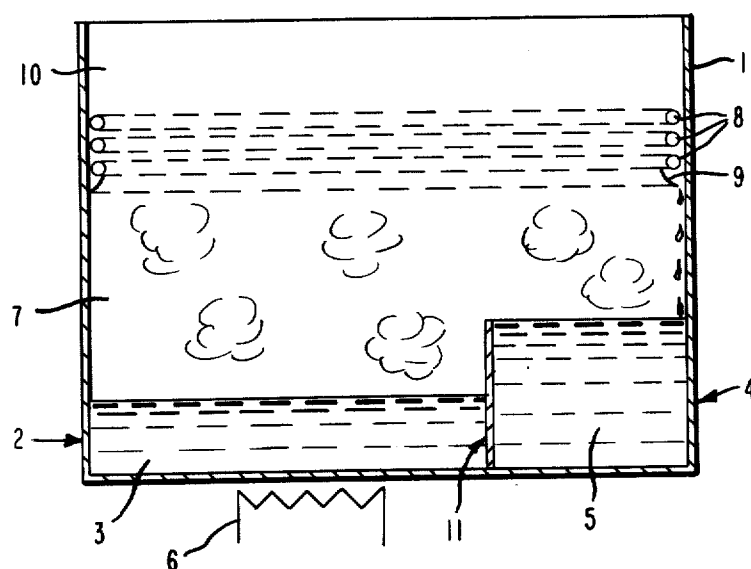
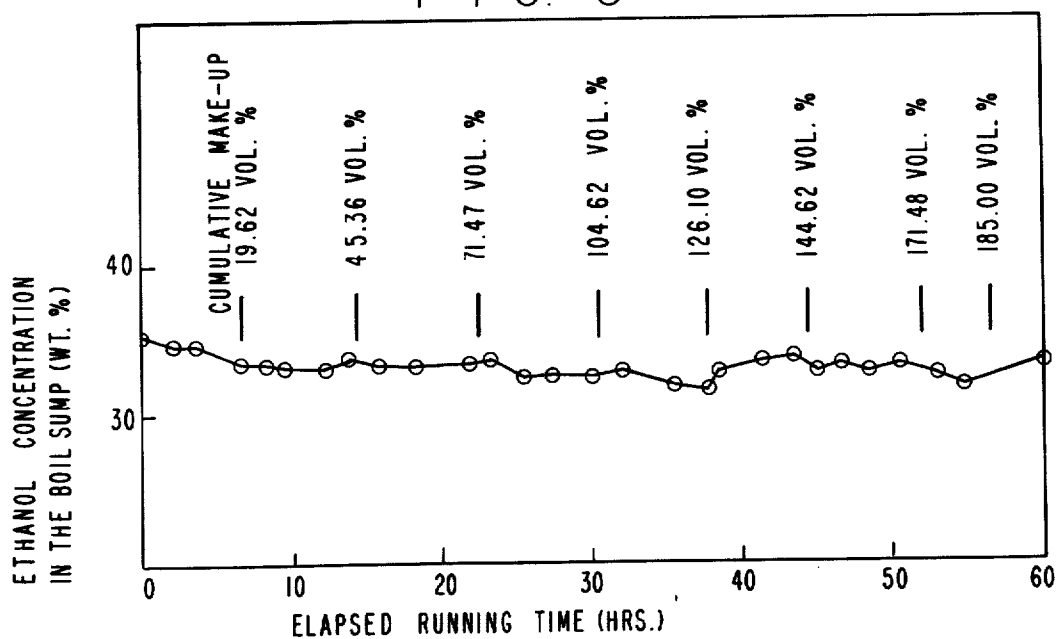
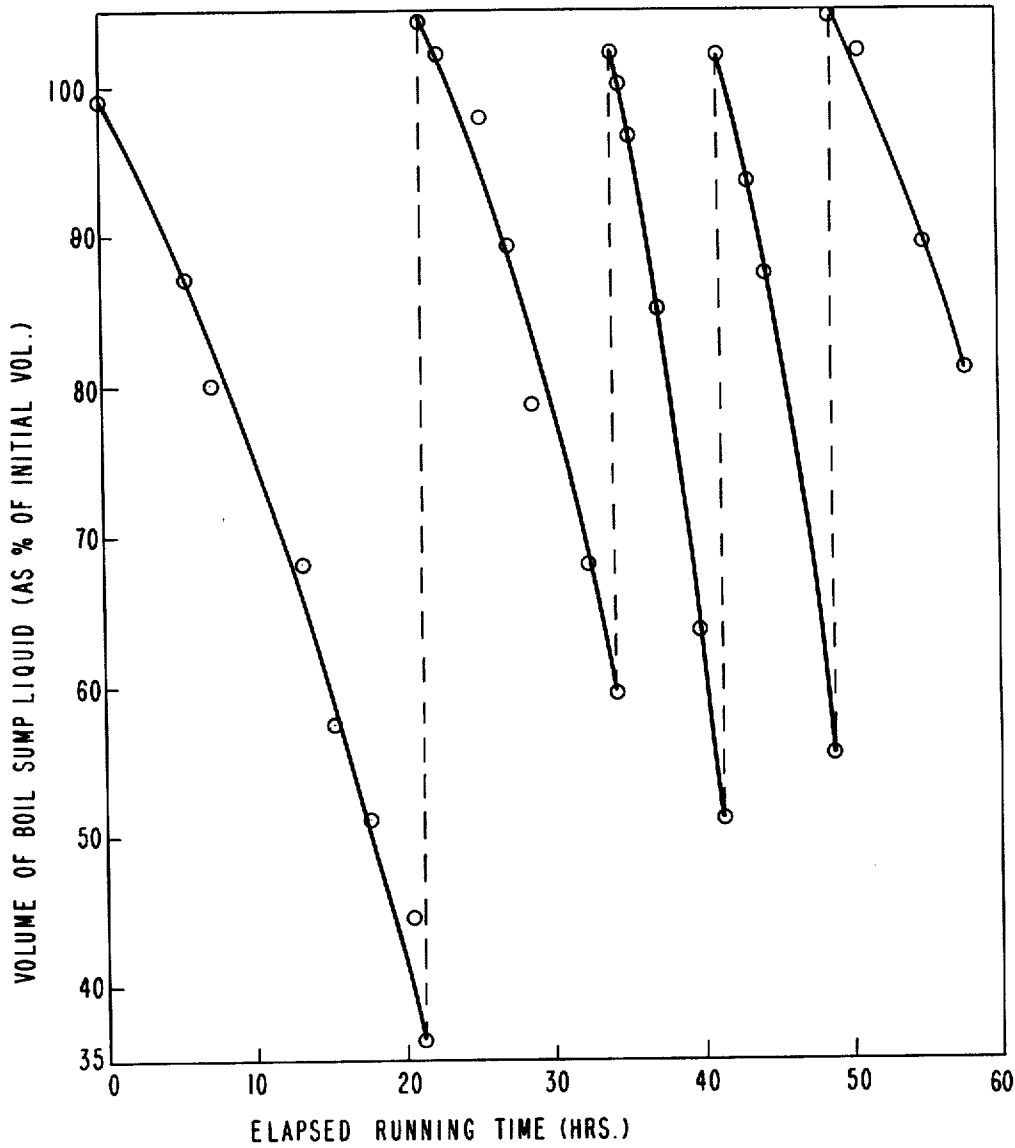


FIG. 3



F I G. 2



VAPOR DEGREASER PROCESS EMPLOYING TRICHLOROTRIFLUOROETHANE AND ETHANOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method for cleaning articles, especially electrical articles, in a vapor degreaser employing trichlorotrifluoroethane and ethanol.

2. Description of the Prior Art

Prior art vapor degreasers usually comprise an open top enclosure having at least one sump, containing a boiling solvent (boil sump liquid), and condenser means. The enclosure and condenser provide means for containing and condensing the normally heavier-than-air vapors generated by the boiling solvent. There is provided within the enclosure a vapor space above the boil sump liquid, a vapor-air interface in the region of the condensing means and a region of quiescent air above the vapor-air interface. Characteristic of prior art vapor degreasing processes, as opposed to other solvent degreasing processes, is the condensation of solvent vapors on the article being cleaned.

Most prior art degreasers comprise also at least one normally unheated rinse sump; the condensate from the condenser is directed to the rinse sump to maintain the rinse sump full with distilled solvent (rinse sump liquid). Flow of rinse sump liquid over a weir separating the boil sump from the rinse sump returns the excess rinse sump liquid to the boil sump. In degreasers of this kind articles to be cleaned are normally passed through the boil sump liquid and thereafter through the rinse sump liquid. The rinse sump liquid not only rinses the article but it cools the article so that on removal from the liquid, vapors in the vapor space condense on the article surfaces to provide a final rinse with freshly distilled solvent. The condensing vapors reheat the article so that on removal to the region of quiescent air above the interface, the article quickly dries; the bulk of the vapors generated during such drying return, by virtue of their normally greater-than-air density, to the vapor space.

Some prior art degreasers comprise an external condensate system; condensate from the condenser is diverted in part to a hold tank fitted with a normally flexible tube communicating with a nozzle, ordinarily hand held, for spraying articles in the vapor space. A pump for propelling the condensate is usually provided. The sprayed condensate may perform the functions of a rinse sump liquid or it may supplement the functions of that liquid.

Many commercial degreasers are fitted with automatic safety and convenience devices. Such devices include float-actuated switches which function to maintain the boil sump liquid volume constant by adding make-up liquid from a reservoir as needed. Some devices include float-actuated switches which operate to shut off heat provided to the boil sump if the volume of the boil sump liquid falls so low as to risk overheating the residue of the sump.

Vapor degreasing is often employed for the removal of flux from soldered circuit boards. A typical circuit board consists of a thin plate normally of epoxy resin reinforced with glass fibers and carrying electrical connectors, usually on only one side, consisting of thin strips of copper. Electronic components are normally placed on the side opposite the connectors and, by

means of leads passing through holes in the board, are attached to the connectors by crimping and the like, followed by soldering. Soldering is carried out by first coating the connector side of the board with a flux and then passing that side of the board over the surface of molten solder. The fluxes employed in this use consist for the most part of rosin. Increasingly popular in the trade are rosin fluxes which are activated by the addition of ionic materials such as oxalic acid derivatives and amine hydrochlorides, typically trimethylamine hydrochloride. The activators ensure better solder bonds, especially on slightly corroded connectors and leads.

The choice of a solvent for the removal of the flux is restricted by the requirement that the solvent not attack the board or the various materials of construction of the electronic components. Alcohols have been used; however, their use is limited because of the severe danger of fire. The known nonflammable azeotropic mixture of 1,1,2-trichloro-1,2,2-trifluoroethane, a mild nonflammable solvent, and 4 weight percent of ethanol has been widely used. Being azeotropic, the mixture does not separate distillatively into its components and there is no danger of accumulation in the boil sump of flammable mixtures containing high concentrations of ethanol. The mixture may be undesirable if, due to the materials in the activated flux used, it leaves a white residue on the board and on the components. The mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 35 weight percent ethanol has been used in cold defluxing operations wherein the boards are dipped in the mixture at room temperature and then allowed to dry. Attempts to use such a mixture in the degreaser mode of operation have led to the formation of mixtures having high concentrations of ethanol in the boil sump and to the formation of flammable vapors in the vapor space.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a process permitting the safe use in a vapor degreaser of boil sump liquids which initially comprise 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol, the latter in excess of the azeotropic amount. A further object is to provide a vapor degreaser process for the defluxing of circuit boards, said process employing boil sump liquids comprising 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol, the latter in excess of the azeotropic concentration. Another object is to provide such a process whereby improved defluxing, particularly with respect to the removal of the white residue hereinbefore described, is realized without formation of flammable vapors in the vapor space.

In summary, the invention herein resides in an improvement in the prior art method of cleaning articles in a vapor degreaser which is open to the atmosphere and comprises:

- a boil sump containing a boil sump liquid;
- at least one rinse sump which contains a rinse sump liquid and has an overflow means so that overflow rinse sump liquid gravitationally flows into the boil sump;
- a means for condensing vapors of the boil sump liquid;
- a means for diverting condensed vapors to the rinse sump; and
- a vapor space between the condensing means and the boil and rinse sumps,

said boil and rinse sump liquid consisting essentially of 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol and said method comprising:

- a. boiling the boil sump liquid;
- b. introducing articles to be cleaned into the degreaser and passing the articles through at least the vapor space of the degreaser;
- c. condensing the vapors of the boil sump liquid;
- d. adding 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol as necessary to maintain the liquid volume of the system; and
- e. removing the articles from the degreaser.

In the improved process of this invention the vapors of the boil sump liquid are maintained in a nonflammable condition by:

- a. employing a boil sump liquid consisting essentially of 35–85 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 15–65 weight percent of ethanol;
- b. employing a rinse sump liquid consisting essentially of 88–100 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 0–12 weight percent of ethanol;
- c. adding to maintain the liquid volume of the system a make-up liquid mixture consisting essentially of 90–97 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 3–10 weight percent of ethanol in such amount that the volume of the boil sump liquid is at least the volume calculated from the equation

$$v_m = \frac{v_i}{100} [(1.44 c_b + 2.30 c_r - 24.1) \pm 2]$$

wherein

v_m = minimum permissible volume of boil sump liquid,

v_i = initial volume of boil sump liquid,

c_b = initial weight percent concentration of ethanol in the boil sump liquid and

c_r = initial weight percent concentration of ethanol in the rinse sump liquid; and

- d. maintaining the liquid volume in the rinse sump and condensate diverting means at least equal to the initial liquid volume in the boil sump.

If the volume of the boil sump liquid is allowed to decrease below the volume determined (as a range) by the aforesaid equation, the vapors in the vapor space will become flammable.

It is to be understood that the ethanol employed in the process of this invention can be pure ethanol or the commonly used denatured ethanols which are readily available. It is to be further understood that the articles being passed through the degreaser may be conveyed in any manner known in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a conventional 2-sump vapor degreaser.

FIG. 2 is a graph relating boil sump liquid volume to time in an experiment wherein make-up liquid was added intermittently to the boil sump.

FIG. 3 is a graph relating the concentration of ethanol in the boil sump liquid to time during an 8-day experiment wherein the volume of the boil sump liquid was maintained essentially constant.

DETAILED DESCRIPTION OF THE INVENTION

The invention herein resides in the discovery that vapor degreasers can be operated effectively and safely employing mixtures of 1,1,2-trichloro-1,2,2-trifluoroethane and greater than azeotropic amounts (that is, greater than 4 weight percent) of ethanol provided there is adherence to the aforesaid improved process conditions.

Although it is not preferred, rinse sump liquids containing concentrations of ethanol above the limit defined above can be charged and flammability still can be minimized if the boil sump liquid has a sufficiently low concentration of ethanol. Shortly after start-up the concentration of ethanol increases in the boil sump liquid and decreases in the rinse sump liquid, thus placing both concentrations within the defined limits for the initial concentrations of ethanol in the two liquids. Thereafter, the concentration of ethanol in each sump liquid may or may not change substantially during use depending on the manner in which the invention process is carried out, but in any event, the concentration of ethanol in the boil sump liquid remains higher than the concentration of ethanol in the rinse sump. For this reason and because it is only the boil sump liquid which is boiled, it is the concentration of ethanol in the boil sump liquid which is controlling as to the flammability of the vapors in the vapor space.

The principal functions of the rinse sump, as already stated, are to cool the articles (which are warmed by the boil sump liquid) so that the vapors in the vapor space condense thereon in the next step and to rinse the bulk of the relatively dirty boil sump liquid from the articles. As to these functions, the ethanol concentration in the rinse sump liquid is unimportant. Similar considerations apply to condensate which may be diverted to a hold tank and employed as a spray liquid. The invention criteria are mainly directed to the maintenance of boil sump liquid compositions which cannot produce flammable vapors in the vapor space; the concentration of ethanol in the rinse sump liquid is allowed to equilibrate or to approach equilibrium with the boil sump liquid.

In the normal operation of a degreaser losses of liquid occur by various routes. The best recognized are diffusion across the vapor-air interface (which seems to be the principal route when the degreaser is idling) and drag out (which is the liquid carried out by the degreaser on the articles). In well designed degreasers, when 1,1,2-trichloro-1,2,2-trifluoroethane liquids are employed, these losses amount to about 0.2 lb./hr.-ft.² of vapor-air interface while the degreaser is idling and about 0.5 lb./hr.-ft.² when the degreaser is working, that is, when articles are being passed through the degreaser. Naturally, the magnitude of the working losses vary according to the type of article being treated. Losses from degreasers are reflected in a lowering of the volume of the boil sump liquid. In processes employing mixtures comprising 1,1,2-trichloro-1,2,2-trifluoroethane and greater than 4 weight percent of ethanol, such losses cause the concentration of ethanol to rise in the boil and rinse sump liquids. It is usual in the operation of vapor degreasers employing conventional liquids to add make-up liquid to one of the sumps to compensate for losses. In carrying out the instant invention, two criticalities must be observed. The first of these pertains to the volume of the boil sump liquid, the

other pertains to the maximum permissible concentration of ethanol in the make-up liquid. In order to avoid eventual flammability of the vapors in the vapor space, it has been found that the concentration of ethanol in the make-up liquid must not exceed about 10 weight percent. As it is desired to maintain a sufficient concentration of ethanol in the boil sump liquid to ensure adequate defluxing, this being the principal utility of the invention, a concentration of ethanol of not less than about 3 weight percent in the make-up liquid is necessary.

It is preferred to maintain the volume of the boil sump liquid essentially constant to minimize fluctuations in the concentration of ethanol in the boil sump liquid. Although make-up liquids containing any concentration of ethanol within the defined limits can be used, it is preferred to employ ethanol concentrations given by the equation

$$C_m = 4.19 + 2.51 \times 10^{-5} c_b^3 \text{ wherein}$$

c_m = the weight percent concentration of ethanol in the make-up liquid and

c_b = initial weight percent concentration of ethanol in the boil sump liquid.

By employing this equation to determine the concentration of ethanol in the make-up liquid, the concentration of ethanol in the boil sump liquid is maintained more nearly constant.

In a nonpreferred embodiment, if the ethanol concentration which is employed in the make-up liquid is greater than c_m , but not greater than 10 weight percent, then the value used for c_b to determine the volume of the boil sump liquid by the equation given earlier above no longer is applicable, in which case a new value of c_b must be determined and the volume of boil sump liquid must be recalculated.

Although it is possible to operate the process of this invention with safety at concentrations of ethanol as high as 65 weight percent in the boil sump liquid, it is preferred to employ a concentration of about 35 weight percent of ethanol in this liquid. Moreover, because of the higher cost of pure ethanol, it is preferred to prepare the liquids required by this invention from denatured ethanol. The denaturants commonly used are present in low concentrations and do not affect the essential properties of ethanol as they pertain to the invention. The preferred denatured ethanol contains about 9 weight percent of methanol and this type of ethanol has been employed in the following examples.

FIG. 1 shows a conventional prior art degreaser. An open-top housing 1 encloses the components of the device. A boil sump 2 containing boil sump liquid 3 and rinse sump 4 containing rinse sump liquid 5 are provided. Heating means 6, normally of the electrical resistance type, is provided to effect boiling of boil sump liquid 3. Vapors from boil sump liquid 3 fill vapor space 7 and are condensed on condenser 8. Condensate from condenser 8 is collected in trough 9 and directed to rinse sump 4. Water separator conduits (not shown) sometimes of substantial volume and intended for the removal of co-condensed water, may be employed at the exit end of trough 9. A vapor-air interface (not shown) is maintained by condenser 8 in the region of condenser 8 between the vapors in the vapor space and quiescent air layer 10. Overflow of rinse sump liquid 5 from rinse sump 4 passes over weir 11 into boil sump 2.

In the following examples and in FIG. 2 reference is made to the minimum safe volume of the boil sump liquid in terms of a percentage of the initial volume of boil sump liquid. It is to be understood that such a percentage, expressed as $v_{\%}$, is calculated by the equation

$$v_{\%} = \frac{v_m}{v_i} \times 100$$

wherein v_m and v_i are as already defined. The prior equation for v_m can thus be written in terms of $v_{\%}$ as $v_{\%} = (1.44 c_b + 2.30 c_r - 24.1) \pm 2$ wherein c_b and c_r are as already defined.

EXAMPLE 1

In this example make-up liquid was added intermittently instead of continuously as is preferred. Between additions the volume of the boil sump liquid decreased as a result of normal idling and working losses. Simultaneously, the concentration of ethanol rose in the boil sump liquid. Except for one instance, as explained below, the vapors generated by the boil sump liquid remained nonflammable. The process was carried out in a laboratory size degreaser having a rinse sump volume of 5.4 liters; the sump was filled with a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 4 weight percent of ethanol. The boil sump was charged with an equal volume of a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 35.2 weight percent of ethanol. The boil sump liquid was boiled in the normal manner for a total of about 58 hours (the running time) during 8 working days. The degreaser was covered during non-running hours. Total loss rates of liquid of between 0.4 and 0.7 lb./hr.-ft.² were realized by passing the following articles through the sumps: during the first 4.5 days of the running time paper towels were used to simulate the treatment of absorbent articles; thereafter, an endless chain was used to simulate the treatment of nonabsorbent articles. The boil sump liquid was replenished four times during the running time. The volume of the boil sump liquid and the concentration of the ethanol therein passed through four and one-half cycles. During the first cycle the volume of the boil sump liquid was allowed to fall to 36.2 percent of the initial volume, that is, within the range $(35.8 \pm 2 \text{ percent})$ calculated for $v_{\%}$ by the aforesaid equation. The vapors in the vapor space were found at this point to be marginally flammable. It is to be understood that the minimum volume of boil sump liquid v_m should not be allowed to decrease below the low end of the range calculated from either of the aforesaid equations for v_m and $v_{\%}$. When the minimum volume is allowed to decrease to within said range, the vapors may or may not be flammable. It is to be further understood that the range recited in either equation is required primarily because of the mathematical difficulties encountered in characterizing the system with such simplified equations, or in other words, in order to avoid recitation of a range a much more detailed and sophisticated equation would have to be derived.

Addition of make-up liquid consisting of 1,1,2-trichloro-1,2,2-trifluoroethane and 4 weight percent of ethanol restored the vapors in the vapor space to a nonflammable condition. During the remainder of the running time, wherein all criteria of the invention were met, the vapors in the vapor space were maintained in a nonflammable condition by maintenance of the boil

sump liquid volume at a value greater than 35.8 ± 2 percent of the initial volume by addition of the aforesaid make-up liquid. From the original concentration of 4 weight percent the concentration of ethanol in the rinse sump (determined by density) increased with decreasing boil sump liquid volume during the first cycle to about 12.7 weight percent; on addition of make-up liquid it decreased to about 6 weight percent. Thereafter, the concentration fluctuated, with variation in the boil sump liquid volume, between about 6.0 weight percent and about 9.9 weight percent. FIG. 2 shows graphically the relationship of boil sump liquid volume (as percent of initial volume) to running time. Dashed lines represent additions of make-up liquid. The slope of the lines during each cycle is proportional to the rate of liquid loss.

EXAMPLE 2

This example demonstrates the operation of a degreaser containing a boil sump liquid having an initial concentration of ethanol at the maximum permissible level. The experiment was carried out as in Example 1 except that the initial charge to the boil sump consisted of a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 65 weight percent of ethanol and the initial charge to the rinse sump consisted of a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 12.1 weight percent of ethanol. Because of the high concentration of ethanol there is much less latitude in the regulation of the volume of the boil sump liquid. In other words, from the equations previously given, it can be calculated that the boil sump liquid volume must be maintained at at least 97.3 ± 2 percent of the initial volume. For this reason the volume of the boil sump liquid was maintained essentially constant by means of a feeder device which operated on demand to add (to the boil sump) make-up liquid consisting of 1,1,2-trichloro-1,2,2-trifluoroethane and 11 weight percent of ethanol. During 29 hours running time, carried out over 4 working days, the volume of the boil sump liquid was maintained by the regulating device, according to measurement of the depth of the liquid, at between 96.3 and 103.7 percent of the initial volume. There was a brief increase to 111.1 percent on the first day due to malfunction of the regulator and a brief decrease to 92.6 percent on the third day. Paper towels, simulating the treatment of absorbent materials, were passed through the sumps at a daily liquid loss rate of about 0.30 to 0.46 lb./hr.-ft.². The vapors in the vapor space were found to be nonflammable on the second day when the measured volume of the boil sump liquid was 96.3 percent of the initial volume; a burning match, when thrust into the vapor space, was extinguished. The boil sump liquid was shown to be nonflammable at the end of the test.

EXAMPLE 3

This example demonstrates a preferred embodiment of the process wherein the following parameters were selected:

1. the initial concentration of ethanol in the boil sump liquid was 35 weight percent;
2. the initial concentration of ethanol in the rinse sump liquid and in the make-up liquid was 4 weight percent; and
3. the volume of the boil sump liquid was maintained essentially constant by continuous (rather than in-

termittent as in Example 1) addition of make-up liquid.

The mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 4 weight percent of ethanol is preferred as initial rinse sump liquid and make-up liquid for reasons of convenience since it represents a known azeotrope. The preferred ethanol concentration for the make-up liquid is 76.1 percent of the permissible concentration calculated from the equation given above for c_m . Surprisingly, the concentration of ethanol in the boil sump liquid remained remarkably constant for an extended period equal to or greater than the usual useful life of the liquids. FIG. 3 shows the concentration of ethanol in the boil sump liquid as a function of time. Also shown is the cumulative, added make-up liquid (in terms of volume percent) as a function of the boil sump liquid volume.

More specific to the above, in this example the degreaser was charged with boil and rinse sump liquids as already described. The boil sump liquid was boiled in the normal manner for about 61 hours over a period of 8 working days. The degreaser was covered during non-working hours. An endless chain was passed through the sumps and to the outside of the degreaser for a sufficient fraction of the running time each day to effect losses of 0.63 to 0.70 lb./hr.-ft.², losses which are at least as high as is normal in industrial practice. On the sixth day 74 grams of activated rosin flux, such as is used in the soldering of circuit boards, were added to the boil sump liquid. From time to time samples were taken from the sumps and assayed for ethanol by hydrometer density measurement at standard temperature. It was established that the presence of flux does not affect the accuracy of the assay within the precision herein reported. The concentration of ethanol in the boil sump liquid as a function of time is shown graphically in FIG. 3. Extrapolation of the results of the figure suggests that the concentration of ethanol in the boil sump liquid would remain within the 30 to 35 weight percent range indefinitely. The vapors of the vapor space were never flammable during the 8 days of the experiment. After equilibrium, which occurred in the first two hours of running time, the concentration of ethanol in the rinse sump liquid remained between 6.2 and 7.2 weight percent.

EXAMPLE 4

This example demonstrates a preferred embodiment carried out in a commercial size degreaser. The degreaser was of the 2-sump type such as shown in FIG. 1 and included an external condensate system not shown in that figure. The rinse sump in horizontal dimensions was 30 inches square and 16 inches deep. The boil sump had the same horizontal dimensions. The boil sump was provided with two float-actuated switches. The first of these operated to open a solenoid valve to admit make-up liquid to the rinse sump from a reservoir as required to maintain the volume of the boil sump liquid essentially constant. The second float-actuated switch was adjusted, as a safety measure, to shut off the electrical heating of the sump if the volume of the boil sump liquid decreased to a predetermined level (below the volume prescribed by either of the aforesaid equations). Since the volume of the boil sump liquid was maintained essentially constant during the course of this experiment, the second switch was never actuated. The rinse sump and the external condensate

system were charged with a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 4 weight percent of ethanol. The rinse sump required 81.8 gallons; the external condensate system, 10 gallons. The boil sump was charged to a liquid depth of 16 inches with 62.3 gallons of a mixture of 1,1,2-trichloro-1,2,2-trifluoroethane and 35 weight percent of ethanol. The make-up liquid reservoir serving the boil sump was charged with the 1,1,2-trichloro-1,2,2-trifluoroethane/ethanol azeotrope. The boil sump liquid was boiled for 63.5 hours over a period of 10 days. The degreaser stood idle on the sixth day. During the course of the experiment, 17 circuit boards were defluxed. The boards were prepared, as is customary in the trade, by coating the circuit side of cleaned boards having wired connections with flux and passing that side of the boards for 5 ± 0.2 seconds over the wiped surface of molten 50:50 Pb:Sn solder held at 464°F. Of the 17 boards of the experiment, 13 were coated with highly activated flux and four were coated with mildly activated flux. Three modes of defluxing were employed. All boards were submerged in the boil sump liquid for 4 minutes. One board coated with highly activated flux was not further liquid rinsed. All other boards were submerged for 15 seconds in the rinse sump liquid. All but one board (coated with highly activated flux) were thereafter sprayed for 15 seconds with condensate in the vapor space. All boards were held 15 seconds in the vapor space. All boards regardless of the defluxing treatment were completely clean. No trace of white residue was visible. The overall liquid loss rate was 0.40 lb./hr.-ft.². During the entire period of the experiment the concentration of ethanol in the boil sump liquid was between 36.0 and 33.5 weight percent. The vapors in the vapor space were nonflammable.

I claim:

1. In a method of cleaning articles in a vapor degreaser which is open to the atmosphere and comprises:

- a. a boil sump containing a boil sump liquid;
- b. at least one rinse sump which contains a rinse sump liquid and has an overflow means so that overflow rinse sump liquid gravitationally flows into the boil sump;
- c. a means for condensing vapors of the boil sump liquid;
- d. a means for diverting condensed vapors to the rinse sump; and
- e. a vapor space between the condensing means and the boil and rinse sumps,

said boil and rinse sump liquid consisting essentially of 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol and said method comprising:

- a. boiling the boil sump liquid;
 - b. introducing articles to be cleaned into the degreaser and passing the articles through at least the vapor space of the degreaser;
 - c. condensing the vapors of the boil sump liquid;
 - d. adding 1,1,2-trichloro-1,2,2-trifluoroethane and ethanol as necessary to maintain the liquid volume of the system; and
 - e. removing the articles from the degreaser,
- the improvement whereby the vapors of the boil sump liquid are maintained in a nonflammable condition by:
- a. employing a boil sump liquid consisting essentially of 35-85 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 15-65 weight percent of ethanol;
 - b. employing a rinse sump liquid consisting essentially of 88-100 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 0-12 weight percent of ethanol;
 - c. adding to maintain the liquid volume of the system a make-up liquid mixture consisting essentially of 90-97 weight percent of 1,1,2-trichloro-1,2,2-trifluoroethane and 3-10 weight percent of ethanol in such amount that the volume of the boil sump liquid is at least the volume calculated from the equation

$$\frac{v_i}{100} [(1.44 c_b + 2.30 c_r - 22.1)]$$

wherein

v_m = minimum permissible volume of boil sump liquid,

v_i = initial volume of boil sump liquid,

c_b = initial weight percent concentration of ethanol in the boil sump liquid, and

c_r = initial weight percent concentration of ethanol in the rinse sump liquid; and

d. maintaining the liquid volume in the rinse sump and condensate diverting means at least equal to the initial liquid volume in the boil sump.

2. The process of claim 1 wherein the boil sump liquid contains about 35 weight percent of ethanol and the rinse sump liquid and the make-up liquid each contains about 4 weight percent of ethanol.

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