

TITLE OF THE INVENTION

CLEANING AGENT COMPOSITION AND PRECISION CLEANING
METHOD

Background of The Invention

Field of The Invention

The present invention relates to a cleaning agent composition and a precision cleaning method in which a specified cleaning agent is employed. More particularly, the present invention is concerned with a precision cleaning method employed to remove dirt attributed to processing oil, work waste, grease, wax, flux, pitch, finger sebum, etc. from an item to be cleaned such as an optical element, a mechanical part, an electrical or electronic part, a semiconductor part or a jig or tool used in working them with the use of a cleaning agent to thereby attain high-quality cleaning. The present invention is also concerned with a cleaning agent composition for hand wiping and a hand wiping cleaning method. The terminology "hand wiping cleaning" used herein means cleaning an item surface by wiping it by hand with fibrous matter impregnated with a cleaning agent composition.

Discussion of Related Art

With respect to an optical element and a semicon-

ductor part, the material undergoes various working steps and also various inspection steps corresponding to the workings before being formed into the product. While the material is passed through such steps, various dirt particles adhere thereto. Cleaning for removing such dirt particles must be carried out taking into account the influence of the cleaning on the material, so that cleaning quality requirements are very strict. The conventional precision cleaning method for optical elements is conducted in the sequence of organic solvent → water-base cleaning agent → water → isopropanol (IPA) → freon as described on pages 193 to 195 of "Precision Cleaning Technology Manual" published by New Technology Development Center, Japan. Various modifications have been effected which include replacing the isopropanol with a dewatering agent comprising freon and, added thereto, a surfactant and also replacing the final freon with vapor cleaning. Without exception, the conventional cleaning methods employ a cleaning line composed of a multiplicity of cleaning agents, none of which can be avoided. Further, the above published literature lists cleaning agents and cleaning methods employed in various industrial fields, from which it is apparent that wide use is made of chlorinated solvents and specified freons.

Mechanical parts have been freed of dirt by dipping them in a chlorinated solvent such as trichloroethane, trichloroethylene or methylene chloride or a hydrocarbon solvent such as kerosene, benzene or xylene and applying thereto ultrasonic and/or barreling. On the other hand, electrical and electronic parts have been freed of dirt with the use of, mainly, a chlorinated solvent such as trichloroethane or a freon solvent such as freon 113.

However, in recent years, substitution for the above cleaning agents has increased in consideration of the global atmosphere problem and orientation toward safety. For example, Japanese Patent Application Laid-Open Specification No. 4076/1993 proposed a cleaning method for mechanical parts comprising removing dirt with the use of a cleaning agent composed mainly of a hydrocarbon having a boiling point of 100 to 350°C and finishing with the use of a completely fluorinated compound having a boiling point of 80 to 200°C, which method was described as being excellent in cleaning and finishing performance and permitting short-time drying. Japanese Patent Application Laid-Open Specification No. 43893/1993 describes cleaning with the use of a cleaning agent composition composed mainly of a hydrocarbon fraction of 150 to 240°C in boiling point which is

substantially free of naphthalene and biphenyl. Further, Japanese Patent Application Laid-Open Specification No. 210092/1989 describes a precision cleaning drying method in which an item having passed through a cleaning step and dipping in pure water is lifted at a very low rate from the liquid level into a dry gas. Still further, Japanese Patent Application Laid-Open Specification No. 17148/1993 describes a cleaning method in which a hydrocarbon-based organic solvent is heated and sprayed at a reduced pressure. On the other hand, with respect to the hand wiping cleaning agent, Japanese Patent Application Laid-Open Specification No. 25499/1993 proposed a cleaning agent for brake device comprising 20 to 97% by weight of cyclopentane and 3 to 60% by weight of an aliphatic monohydric lower alcohol having 1 to 3 carbon atoms along with the balance of a hydrocarbon having 6 to 8 carbon atoms. Moreover, a variety of other cleaning agents such as a water-base cleaning agent, a cleaning agent composed mainly of a glycol ether and a cleaning agent composed mainly of a terpene, e.g., limonene have been proposed.

In recent years it has become apparent that a chlorinated solvent such as trichloroethane and a specified freon such as freon 113 are chemically stable and, upon evaporation, arrives at the ozonosphere where

they are decomposed by ultraviolet rays to liberate halogen from the molecules thereof, which destructs the ozonosphere surrounding the earth. The prohibition of industrial use thereof became effective in 1995 and the application thereof to industrial cleaning is no longer permitted.

Although being excellent in cleaning and drying performance and advantageous in cost, the hydrocarbon solvent such as kerosene or benzene is a substance regulated by the organic solvent control regulation, has been demonstrated to be highly carcinogenic and has problems with respect to the nonhazardousness to human and smell. Further, its purity is so poor that the problem is encountered that, for example, stain occurs in the drying to thereby disenable attaining high-quality item finishing.

The cleaning agent composed mainly of a glycol ether has drawbacks in that the smell is strong when use is made of one having excellent cleaning performance and that the dryability is generally poor. The cleaning agent composed mainly of a terpene such as limonene has problems that it emits strong smell although being excellent in safety and cleaning power and that it is derived from a natural product, so that it lacks quality stability and is highly expensive.

On the other hand, although the water-base cleaning agent is excellent in safety and cost, the cleaning method using this water-base cleaning agent has a drawback in that the disposal of rinse water, drying and metal rusting must be taken into consideration, there are heavy constraints on the facilities and item to be cleaned.

The cleaning method comprising removing dirt with the use of a cleaning agent composed mainly of a hydrocarbon and finishing with the use of a completely fluorinated compound as described in Japanese Patent Application Laid-Open Specification No. 4076/1993 is excellent in cleaning and finishing performance, permits short-time drying and is advantageously free from the problems of waste water disposal and rusting because of the nonuse of water. However, the problem is encountered that the completely fluorinated compound employed in finishing is highly expensive. Further, an additional problem is encountered that special measures such as improving the hermetic sealing of the cleaning apparatus and attaching a vapor recovery device must be taken for limiting the consumption of the completely fluorinated compound to thereby complicate the apparatus and render the control thereof difficult.

The cleaning agent composition described in Japa-

nese Patent Application Laid-Open Specification No. 43893/1993 is advantageous in that it is free from environmental pollution, excellent in dirt removing capability and available at low cost. However, it is a mixture of a multiplicity of hydrocarbons, so that stain is likely to occur on the surface of the cleaned and dried item. Thus, the use of this cleaning agent composition in precision cleaning involves difficulties. Further, the 100% removal of aromatic hydrocarbons suspected of carcinogenesis is unfeasible, so that the problem is encountered that not only is nonhazardousness to human not ensured but also the smell is strong.

The cleaning method using pure water and dry gas as described in Japanese Patent Application Laid-Open Specification No. 210092/1989 needs a large amount of energy in the heating and drying because of large specific heat and large latent vaporization heat. Further, this cleaning method involves not only the problems that dewing occurs on the surface of the cleaned item at the time of drying, large surface tension prevents penetration into minute regions and the surface of the metal material is rusted but also the problem that production of pure water and dry gas causes cost increase and complicates the cleaning

apparatus.

In the cleaning method comprising spraying a hydrocarbon solvent as described in Japanese Patent Application Laid-Open Specification No. 17148/1993, the solvent in which, for example, cutting oil liberated by the cleaning has been mixed is simultaneously sprayed to thereby cause the cutting oil to remain on the surface of the cleaned item with detriment to the cleaning quality. Thus, precision cleaning cannot be attained by this method. Periodic solvent replacements would have to be conducted at short intervals for avoiding this detriment, which, however, disadvantageously increases running cost.

In the cleaning method described in Japanese Patent Application Laid-Open Specification No. 25499/1993, cyclopentane as the main component has unique benzene smell to thereby deteriorate the working atmosphere. Further, it damages a plastic such as polystyrene, so that the scope of employable items to be cleaned is limited.

Summary of The Invention

In view of the above drawbacks of the prior art, the object of claims 1 to 14 is to provide a precision cleaning method enabling removing dirt from an item to be cleaned without environmental pollution while ensur-

ing excellent cleaning and drying performance to thereby obtain a high-quality cleaned item. The object of claims 15 to 18 is to provide a cleaning agent composition for hand wiping which has excellent composition stability and excellent dryability. The object of claim 19 is to provide a preferred precision cleaning method in which use is made of the cleaning agent composition of the present invention.

The foregoing and other objects, features and advantages of the present invention will become apparent from the following detailed description and appended claims taken in connection with the accompanying drawings.

Brief Description of The Drawings.

In the drawings:

Fig. 1 is a flow chart showing the cleaning procedure performed in Examples 1 to 8;

Fig. 2 is a sectional view of the cleaning apparatus employed in Example 9;

Fig. 3 is a diagram showing the construction of the cleaning apparatus employed in Example 10;

Fig. 4 is a valving program chart showing valving for each step in Example 10;

Fig. 5 is a graph showing the pressure change vs. step measured in the airtight cleaning vessel in Exam-



ple 10;

Fig. 6 is a diagram showing the construction of the cleaning apparatus employed in Example 11;

Fig. 7 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 19;

Fig. 8 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 20;

Fig. 9 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 24; and

Fig. 10 is a perspective view of a three-points supporting jig employed in Examples 12 to 18.

Detailed Description of The Invention

According to the present invention, there is provided a precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within

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10°C of its initial boiling point in distillation at 760 mmHg. Further, there is provided a precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent, replacing part of the cleaning agent adhering to the item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg. Still further, there is provided a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics. Moreover, there is provided a precision cleaning method comprising impregnating fibrous matter with a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6



carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol so as to exhibit azeotropic or azeotrope-like characteristics and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand.

The saturated hydrocarbon composing the cleaning agent for use in the present invention may be one obtained by first oligomerizing gaseous propylene or butene into a mixture of hydrocarbons and then separating by distillation a fraction having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point at 760 mmHg from the mixture. The above oligomerization of gaseous propylene or butene produces a plurality of specified hydrocarbons with varied boiling points, from which the desired high-purity saturated hydrocarbon can easily be separated by subsequent distillation.

With respect to the saturated hydrocarbon for use in the present invention, the 95% running point falls within 5°C, preferably, within 3°C of its initial boiling point. It is still preferred that the 99.5% running point fall within 5°C, especially, within 3°C

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of the initial boiling point.

The employment of the above limited distillation temperature range reduces high-boiling-point fractions, improves the purity of principal component and enables preventing the inclusion of unsaturated hydrocarbons and aromatic hydrocarbons, so that the smell, stability and nonhazardousness to human can be improved.

When the saturated hydrocarbon has less than 8 carbon atoms, the inflammability thereof unfavorably becomes very high to thereby deteriorate the handling safety. On the other hand, when the number of carbon atoms thereof is greater than 12, the boiling point of the saturated hydrocarbon approaches to those of dirt components such as processing oil, so that the problem is encountered that, in the recycling by distillation regeneration, the separation thereof from the dirt components is difficult.

The saturated hydrocarbon for use in the present invention has a surface tension as low as about 18 to 22 dyne/cm, so that it can easily get into or out of narrow slits and blind holes for screwing. Thus, it can remove dirt from a highly uneven item of complicated configuration to thereby ensure excellent cleaning capability. Naturally, the cleaning agent consisting essentially of the saturated hydrocarbon according to

the present invention possesses the advantageous properties of the conventionally employed hydrocarbon cleaning agents, i.e., freedom from the danger of environmental pollution, very low cost and antirusting properties.

Further, the latent vaporization heat of the saturated hydrocarbon is relatively low, i.e., ranging from 60 to 70 cal/g, so that the vaporization thereof scarcely lowers the surface temperature of the item to thereby have the advantage of being free from the danger of dewing of atmospheric steam on the surface of the item. In contrast, when use is made of a hydrophilic solvent having a high latent vaporization heat such as water or isopropanol, the vaporization thereof deprives the item of a conspicuous amount of vaporization heat to thereby cause a rapid drop of the surface temperature of the item with the result that steam dewing occurs. Thus, the problem is encountered that stain would result and finishing quality would be deteriorated.

In the present invention, it is preferred that an isoparaffin be used as the saturated hydrocarbon. The saturated hydrocarbons include n-paraffins, isoparaffins and naphthenes. While isoparaffins are excellent in cleaning capability, smell and nonhazardousness to

human, n-paraffins are inferior to isoparaffins in cleaning capability and smell and naphthenes are inferior to isoparaffins in smell and nonhazardousness to human. Thus, the use of isoparaffins is preferred. It is especially preferred that the saturated hydrocarbon be principally composed of isononane having 9 carbon atoms. The isoparaffins having 8 to 12 carbon atoms per molecule include isooctane, isononane, isodecane, isoundecane and isododecane. Isononane is preferred to the others in cleaning capability and fire protection law regulations. Whilst isooctane belongs to petroleum of flash point classification no. 1 of dangerous commodity and its unit stock is limited to 200 liters in accordance with the regulation of fire protection law, isononane belongs to petroleum of flash point classification no. 2 of dangerous commodity and its unit stock can advantageously be as large as 1000 liters. On the other hand, isodecane, isoundecane and isododecane are inferior to isononane in cleaning capability.

In a specific mode of the present invention, the precision cleaning method comprises removing dirt from an item to be cleaned with the use of a cleaning agent (the cleaning agent of saturated hydrocarbon according to the present invention or another cleaning agent), replacing part of the cleaning agent adhering to the



item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further treated with the cleaning agent of the present invention which consists essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg. In this mode of the present invention, it is preferred that an isoparaffin be used as the saturated hydrocarbon. It is especially preferred that the saturated hydrocarbon be principally composed of isononane having 9 carbon atoms. With respect to the saturated hydrocarbon for use in this mode of the present invention, the 95% running point falls within 5°C, preferably, within 3°C of its initial boiling point. It is still preferred that the 99.5% running point fall within 5°C, especially, within 3°C of the initial boiling point.

It is required that the cleaning agent for removing dirt solubilize the dirt, be able to get into and out of minute hollow and do not affect the surface of the item to be cleaned. The cleaning agent of saturated hydrocarbon according to the present invention is highly miscible with dirt components such as processing

oil, grease and wax and can rapidly solubilize them. Moreover, the cleaning agent of the present invention has a surface tension as low as about 18 to 22 dyne/cm, so that it can easily get into or out of, for example, slits and minute hollow such as screwing sites of the item to be cleaned. Thus, it can remove dirt from a highly uneven item of complicated configuration.

The cleaning agent used just before the drying step is generally called "finishing liquid", "drying liquid" or "rinse". This cleaning agent is used to replace the cleaning agent used in the previous step and contaminated, i.e., to rinse so that the item surface is finished clean prior to the drying. This cleaning agent is desired to be highly purified, especially, to exhibit distillation profile falling within a given limited range. When use is made of a cleaning agent of distillation profile having a broad boiling point range, lifting of the item from the cleaning agent after dipping would be followed by evaporation of low-boiling-point components with the remaining of high-boiling-point components. As a result, a thin film of cleaning agent formed on the surface of the cleaned item becomes nonuniform, so that the problem is encountered that stain residue occurs on the surface of the item. In the present invention, use is made of the

cleaning agent of saturated hydrocarbon whose distillation temperature range is limited narrow. The cleaning agent of saturated hydrocarbon used in the present invention has a reduced amount of high-boiling-point components, so that the purity of principal component is enhanced. Thus, the above stain residue does not occur in the present invention.

In the present invention, the finishing quality can further be improved by lifting the cleaned item at a rate of not greater than 70 mm/s from the cleaning agent prior to the drying. When the cleaned item dipped in the above cleaning agent is lifted prior to the drying, a thin film of cleaning agent adheres to the surface of the cleaned item because of the viscosity of the cleaning agent. The thin film is elevated in accordance with the lifting of the cleaned item. On the other hand, the cleaning agent per se has cohesive force and surface tension, so that the liquid level of the cleaning agent is slightly elevated by the lifting of the cleaned item. The limitation of the lifting rate to not greater than 70 mm/s enables forming a uniform thin film of cleaning agent to thereby accomplish finishing without the occurrence of residue. In contrast, when the lifting is conducted at a rate of greater than 70 mm/s, the formed thin film of cleaning

agent cannot be uniform and the cleaning agent remains on the surface of the cleaned item in the form of spots or blocks to thereby cause the danger of stain occurrence.

In a further specific mode of the present invention, the precision cleaning method comprises vaporizing a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg and applying the vapor to an item to be cleaned so that the item to be cleaned is freed of dirt and/or dried. The vaporization of the cleaning agent is conducted by heating at boiling point or higher under atmospheric pressure or by heating while reducing the pressure. In the latter vaporization method, the above highly purified saturated hydrocarbon is introduced in a vaporization vessel having its internal pressure reduced to about 60 mmHg and heated. The internal pressure of the vaporization vessel becomes equal to the vapor pressure at heating temperature of the saturated hydrocarbon because of the vapor-liquid equilibrium. When the heating is performed at temperatures not greater than the boiling point under atmos-

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spheric pressure, the inside of the vaporization vessel has a negative pressure, so that the leakage of the solvent vapor (vapor of saturated hydrocarbon) to the atmosphere does not occur.

The supply of the solvent vapor (vapor of saturated hydrocarbon) onto the item to be cleaned is conducted by reducing the internal pressure of the airtight cleaning vessel or other treatment vessel to be supplied with the solvent to an about 100 mmHg negative pressure as compared with the internal pressure of the vaporization vessel. The vapor is initially supplied in an amount corresponding to the pressure difference of 100 mmHg. The overall pressure at that instance is slightly lower than the initial internal pressure of the vaporization vessel. Thus, the vaporization of the saturated hydrocarbon is advanced because of the restoration to the initial equilibrium state to thereby accomplish vapor supply.

In contrast, when use is made of the common hydrocarbon solvent, the distillation temperature range is as large as 20 to 30°C, so that the compositions (component ratios) are conspicuously different between the vapor phase and the liquid phase at the vapor-liquid equilibrium. Therefore, when the heating is conducted at the same temperature, the ratio of low

boiling point components is high in the vapor phase while the ratio of high boiling point components is high in the liquid phase. Consequently, when comparison is made between the vapor-liquid equilibrium at the initial liquid supply and that after the passage of some time, it is found that the vapor pressure is higher and the amount of the vapor is greater at the initial liquid supply. However, the heating is conducted by low-boiling-point vapor at the vapor supply, so that it may occur that the item to be cleaned is not supplied with a quantity of heat satisfactory for achieving the drying to thereby failing to dry the item. Low-boiling-point components evaporate and are lost and the amount of high-boiling-point components is increased with the passage of time, resulting in a drop of the overall vapor pressure. Therefore, with respect to the common hydrocarbon solvent, not only is control of the level of pressure reduction of the airtight treatment vessel required but also the quantity of heat must be increased to maintain the constant pressure.

The saturated hydrocarbon used in the present invention is one whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg. Thus, the compositions are

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the same between the liquid phase and the vapor phase at the vapor-liquid equilibrium, so that the change of equilibrium is slight irrespective of the passage of time. In contrast, the common hydrocarbon solvent has a multiplicity of components, so that the compositions are different between the liquid phase and the vapor phase with the result that the vapor phase has a composition enriched with low-boiling-point components while the liquid phase has a composition enriched with high-boiling-point components. With respect to this hydrocarbon, the vaporized composition cannot be constant and the liquid phase composition changes to higher boiling points with the passage of time, so that the quantity of heat for vaporizing the solvent must be increased with the result that the operation under the same conditions becomes impossible. However, the cleaning agent of saturated hydrocarbon employed in the present invention has little change in the vapor-liquid equilibrium, so that it can stably be used.

After the supply of heat to the item to be cleaned by means of vapor supply, the internal pressure of the treatment vessel is reduced by a vacuum pump. This pressure reduction accelerates the vaporization of the solvent adhering to the item. The quantity of heat provided by the heat supply is such that the tempera-

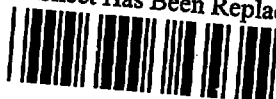
ture is raised to about 110°C with respect to a highly purified saturated hydrocarbon having 8 carbon atoms and about 180°C with respect to a highly purified saturated hydrocarbon having 12 carbon atoms. The evaporation of the solvent requires a vaporization heat, which utilizes the heat provided by the vapor supply to thereby enable evaporation of the solvent. Then, leakage is effected after the passage of a given period of time so that the inside of the vessel is restored to atmospheric pressure to thereby complete the process.

As apparent from the above, the present invention characteristically employs the cleaning agent of saturated hydrocarbon whose distillation temperature range has been limited narrow.

In still a further specific mode of the present invention, the precision cleaning method comprises the steps of dipping an optical element to be cleaned in an organic solvent and/or a water-base cleaning agent to thereby remove dirt, dipping the optical element in water to thereby rinse off the organic solvent and/or water-base cleaning agent adhering to the optical element, dipping the optical element in a hydrophilic solvent to thereby replace the water adhering to the optical element therewith, dipping the optical element

in a water insoluble solvent to thereby replace the hydrophilic solvent adhering to the optical element therewith and drying the optical element to thereby remove the water insoluble solvent from the optical element for finishing, wherein the water insoluble solvent consists essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg. In this method, the first dipping of the optical element in the organic solvent and/or water-base cleaning agent removes most of dirt components such as pitch, wax, abrasive, finger sebum and dust therefrom. A variety of organic solvents can be used which include chlorinated solvents such as trichloroethylene and 1,1,1-trichloroethane, petroleum solvents such as alkylbenzenes and naphthenes, terpene solvents such as limonene and dipentene, glycol ether solvents such as diethylene glycol monobutyl ether and dipropylene glycol monomethyl ether and ester solvents such as ethyl lactate and dimethyl succinate. Examples of the water-base solvents include alkali cleaning agents comprising water and a small amount of additives such as a surfactant, an alkali builder and an antifoaming

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agent and neutral cleaning agents composed of a surfactant as a principal ingredient. In practice, a suitable organic solvent and a suitable water-base cleaning agent are selected taking into account various conditions such as the type of adhering dirt, strength of dirt adhesion, etc. The cleaning may be performed by either using first an organic solvent and then a water-base cleaning agent or using a water-base cleaning agent only.

Subsequently, the thus cleaned optical element is dipped in water to thereby rinse off the water-base cleaning agent. Additives such as a surfactant and an alkali builder often erode the surface of the optical element, so that these must satisfactorily be removed in this step. The rinse is generally more effective when the water temperature is high than when the water temperature is low. The rinse may also be performed by alternating dipping in water of low temperature, for example, 20°C and dipping in water of hot temperature, for example, 60°C. With respect to the type of water, pure water is preferred but city water and well water may also be used.

Thereafter, the optical element is dipped in a hydrophilic solvent to thereby replace the water adhering to the optical element therewith. The hydrophilic

solvent is not particularly limited as long as it can dissolve water and can remove the water adhering to the optical element therewith. Generally, isopropanol (IPA) or ethanol is used as the hydrophilic solvent from the viewpoint of capability of replacing water and cost.

Still thereafter, the optical element is dipped in the cleaning agent of saturated hydrocarbon according to the present invention to thereby replace the above hydrophilic solvent. Application of physical force such as oscillation or jet is effective in increasing the velocity of replacing the hydrophilic solvent with the saturated hydrocarbon. In particular, application of ultrasonic vibration of 20 kHz to 100 kHz in frequency is most effective in increasing the velocity. Specifically, in the first tank charged with the cleaning agent of saturated hydrocarbon, application of physical force is especially effective in increasing the velocity of replacement because a large amount of hydrophilic solvent is adhering to the optical element. When ultrasonic vibration is applied, the adhering hydrophilic solvent is atomized and compulsorily dispersed, so that the dispersibility thereof into the saturated hydrocarbon is increased. The saturated hydrocarbon employed in this method may be an isoparaf-

fin or may be principally composed of isononane having 9 carbon atoms.

Finally, the cleaning agent of saturated hydrocarbon adhering to the optical element is vaporized to thereby dry and finish the optical element. Various drying methods are available which include the method in which hot air of about 80°C cleaned by passing it through a precision filter to thereby remove dust is blown to the above optical element so that the saturated hydrocarbon is vaporized, the method in which the optical element is irradiated with far infrared radiation and the method in which the vaporization is effected in vacuum. The drying method is not particularly limited as long as not only can uniform drying be conducted without the sticking of additional dirt such as dust but also the saturated hydrocarbon is completely removed.

In the step of replacing the hydrophilic solvent according to the present invention, not only can the optical element be finished with high quality ensured but also the performance of the cleaning agent can be maintained for a prolonged period of time by separating off the hydrophilic solvent mixed in the cleaning agent of saturated hydrocarbon with the use of water. Generally, if all the components of the cleaning agent have

mutually identical vaporization rates in the step of vaporizing off the cleaning agent adhering to the optical element, the film of cleaning agent adhering to the optical element is uniformly thinned and finally completely vaporized to thereby enable high-quality finishing without the occurrence of stain. However, if the components of the cleaning agent have vaporization rates different from each other, readily vaporizable components first vaporize while components whose vaporization is difficult remain in spots with the result that uniform drying cannot be effected. Dust or other matter coheres at spotted parts, so that stain results to thereby disenable high-quality finishing. When a hydrophilic organic solvent is carried from the previous tank, its vaporization rate is different from that of the cleaning agent of saturated hydrocarbon according to the present invention, so that stain is caused. Further, the hydrophilic organic solvent is likely to absorb moisture of the air, so that the water content thereof increases. Water is one of the major causes of staining. Therefore, the concentrations of the hydrophilic organic solvent mixed in the cleaning agent of saturated hydrocarbon and the water contained therein must be controlled low. For the control of the concentrations of the hydrophilic organic solvent mixed in

the cleaning agent of saturated hydrocarbon and the water contained therein, a hydrophilic organic solvent removing device capable of continuously removing these is connected to the tank charged with the cleaning agent of saturated hydrocarbon so that the cleaning agent of saturated hydrocarbon can be recycled.

The above hydrophilic organic solvent removing device comprises a vessel accommodating water in its lower part and a cleaning agent of saturated hydrocarbon in its upper part. When the cleaning agent of saturated hydrocarbon mixed with the hydrophilic organic solvent is introduced in the water layer, it floats up because of the specific gravity difference and, during the passage through the water layer, the hydrophilic organic solvent is removed. Means are provided for allowing the cleaning agent of saturated hydrocarbon freed of the hydrophilic organic solvent to be recycled to the replacing tank of the cleaning line. Although being uniformly miscible with the cleaning agent of saturated hydrocarbon, the hydrophilic solvent has greater tendency for dissolution in water. The hydrophilic organic solvent is transferred into the water layer by the passage therethrough with the result that the cleaning agent of saturated hydrocarbon is freed of the hydrophilic organic solvent to thereby

enable controlling low the concentrations of the mixed hydrophilic organic solvent and the water contained therein. Thus, dirt adhering to the optical element can be removed with high quality ensured for a prolonged period of time. The efficiency of dissolution of hydrophilic organic solvent in water is enhanced by atomizing the saturated hydrocarbon mixed with the hydrophilic organic solvent with the use of, for example, a punching plate or a net so as to increase the area of contact with water prior to the introduction into the water layer instead of the simple passage through the water layer.

Moreover, the present invention provides a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics and also provides a precision cleaning method comprising impregnating fibrous matter with this cleaning agent composition for hand wiping and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand.

The aliphatic saturated hydrocarbon and lower alcohol as components of the composition of the present invention contain no halogen elements destructing the ozonosphere in the molecules, so that, even if evaporated and scattered into the atmosphere by the use in cleaning operation, the composition containing them do not adversely affect the ozonosphere and are clearly nonhazardous to the global atmosphere.

The composition of the present invention comprising the aliphatic saturated hydrocarbon having 6 carbon atoms and the lower alcohol having 1 to 3 carbon atoms exhibits azeotropic or azeotrope-like characteristics. The terminology "azeotropic" used herein means the property such that a mixture of a plurality of compounds has a single stable apparent boiling point and behaves like a single compound. The boiling point of the azeotropic mixture is lower than that of each of the plurality of compounds forming the azeotropic mixture. Further, with respect to the azeotropic mixture, the component ratios are identical between the vapor phase and the liquid phase at the vapor-liquid equilibrium. The terminology "azeotrope-like" used herein means the property such that a mixture of a plurality of compounds has a boiling point range falling up to 5°C of the boiling point of the azeotropic

composition at atmospheric pressure (760 mmHg) and exhibits behavior approximating to a single compound.

The composition of claim 15, i.e., the cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol has a boiling point ranging from 52 to 55.5°C at atmospheric pressure. This boiling point is significantly lower than those of the components (aliphatic saturated hydrocarbon having 6 carbon atoms and lower alcohol having 1 to 3 carbon atoms) as shown in Table 6.

Table 6

Component	2-methyl-pentane	3-methyl-pentane	n-hexane	methanol	ethanol	n-propa-nol	iso-propanol
b.p. (°C)	60.3	63.3	68.7	64.6	78.3	97.2	82.4

The relative evaluation of drying rate of solvent-based cleaning agent compositions can be made by comparing boiling points. Generally, the lower the boiling point, the greater the drying rate. Therefore, the cleaning agent composition of claim 15 has a drying rate greater than those of the components.

With respect to the above cleaning agent composition, the range of boiling points at atmospheric pressure is within 5°C and the composition exhibits azeotropic or azeotrope-like properties so that the composition change is scarce irrespective of the vaporization or evaporation. Therefore, the composition change attributed to uneven evaporation of cleaning agent components during the cleaning operation can be prevented and uniform cleaning capability can be retained irrespective of the use for a prolonged period of time. Further, the composition change can be avoided in the storage vessel during the storage thereof.

The cleaning agent composition preferably comprises 82 to 88% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 56% by weight of 2-methylpentane and 12 to 18% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol. This cleaning agent composition exhibits azeotropic properties to thereby not only have its boiling point lowered as compared with those of the components thereof but also exhibit a composition change upon distillation as low as less than about 5% with respect to each of the lower alcohol component and the aliphatic saturated hydrocarbon component, which attests to stabili-

zation of the composition. That is, the composition change attributed to the vaporization or evaporation during the cleaning operation is very slight.

The cleaning power will be described below. The cleaning power of the solvent-based cleaning agent composition can be expressed by the dirt dissolving capability. The solubility parameter (hereinafter referred to as "SP") is generally known as a scale for estimating the dissolving capability. The SP value is strongly influenced by the polarity of the compound. Chain compounds such as 2-methylpentane, 3-methylpentane and n-hexane as the aliphatic saturated hydrocarbon being a component of the cleaning agent composition of claim 15 have properties very similar to each other from the viewpoint of polarity because of the molecular structures. On the other hand, methanol, ethanol, isopropanol and n-propanol as the lower alcohol component have also properties very similar to each other from the viewpoint of polarity. Therefore, the cleaning power is influenced by the ratio of the component of aliphatic saturated hydrocarbon as an aggregate of 2-methylpentane, 3-methylpentane and n-hexane to the component of lower alcohol as an aggregate of methanol, ethanol, isopropanol and n-propanol.

For example, finger sebum, marking ink, waxes such

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as pitch and fluxes such as rosin oil can be mentioned as the object to be removed with the use of the cleaning agent composition of claim 15. When it is intended to clean these dirt components by hand wiping or dipping with the use of a cleaning agent composition whose lower alcohol component content is less than 10% by weight, the cleaning power is unsatisfactory for finger sebum, marking ink and rosin oil and removal thereof by hand wiping cleaning becomes difficult. Thus, the content of at least one lower alcohol is required to be at least 10% by weight for obtaining satisfactory cleaning power and is desired to be at least 12% by weight for facilitating the cleaning.

The damage on the item to be cleaned will be described below. The cleaning agent composition of claim 15 is applied to metals, glasses, ceramics, thermoplastic resins and plastic elastomers as the material of the item to be cleaned. The corrosion of these materials caused by dipping or hand wiping cleaning depends on the content of lower alcohol component. When the lower alcohol component ratio ranges from 5 to 50% by weight based on the composition, metals and glasses have no changes and are free from the influence of the cleaning agent composition. Also, thermoplastic resins whose internal stress residue is slight are free from any

problems as long as the lower alcohol component ratio ranges from 5 to 50% by weight based on the composition. However, thermoplastic resin products whose internal stress residue is extensive because of injection or other rework occasionally suffer from cracking or other corrosion effect when the lower alcohol mixture component ratio exceeds 35% by weight based on the composition. Therefore, it is requisite that the ratio of lower alcohol mixture component be not greater than 34% by weight based on the composition for ensuring wide applications to various items to be cleaned irrespective of the type of the material thereof as a cleaning agent. The ratio is preferred to be not greater than 20% by weight based on the composition taking into account safety factor set in consideration of the difference of residual stress level between various products.

The cleaning agent composition of claim 16 is one whose total content of n-hexane, methanol, isopropanol and n-propanol is less than 10% by weight based on all of the composition. This composition ensures greater safety.

Among the components of the cleaning agent composition, n-hexane, isopropanol and methanol are categorized as the Class 2 organic solvent by the organic solvent control regulation of Japanese Industrial

Safety & Hygiene Law. Methanol is further categorized as a poisonous material. Moreover, the permissible concentrations of n-hexane, methanol, isopropanol and n-propanol are 50, 100, 400 and 200 ppm, respectively. These values are lower than the permissible concentrations of other components and, taking safety into account, it is preferred that the total content of n-hexane, methanol, isopropanol and n-propanol be limited.

The cleaning agent composition of claim 17 is one whose water content is less than 2000 ppm by weight so that the composition is substantially free of water. This composition realizes the state of having no stain after drying while maintaining azeotropic or azeotrope-like characteristics, so that the cleaning quality improvement can be attained to thereby enable application to precision cleaning.

When the water content of the cleaning agent composition is high, water is not entirely evaporated even after the evaporation of the cleaning agent composition because water has a very large latent vaporization heat, so that the phenomenon appears that particulate water remains on the surface of the cleaned item. The inventors' study has showed that, when the water content is 2000 ppm or higher, particulate water remains on the

surface of the cleaned item after cleaning and drying and the retarded evaporation of the water causes stain on the surface of the cleaned item. The lower the water content, the more effectively can the staining be suppressed. Therefore, it is preferred that the water content be less than 1000 ppm, especially, less than 500 ppm. The water content of the composition can be reduced by putting an adsorbent or a molecular sieve (for example, commercially available Molecular Sieve) in the composition of the present invention. This method may be applied for controlling the water content.

The cleaning agent composition of claim 18 is one in which the total amount of components having a boiling point of 120°C or higher at 760 mmHg is less than 1% by weight and the total amount of components having a boiling point of 170°C or higher at 760 mmHg is less than 1000 ppm by weight. This composition can satisfactorily be applied to precision cleaning.

There is the possibility that high-boiling-point hydrocarbons and other impurities mix into the aliphatic saturated hydrocarbon to be used as a component of the cleaning agent composition according to the present invention during the process or intermediate step for producing the same. These occasionally remain as residue on the surface of the cleaned item, depending

on the type and content thereof. In the event of the occurrence of residue in the precision cleaning, for example, finish cleaning conducted prior to optical coating of lenses, defects such as peeling of the optical coating film from the lenses would result, so that the contaminated saturated hydrocarbon cannot be employed. The inclusion of high-boiling-point components may cause a drop of the drying rate. The inventors' study has showed that the inclusion of components with a boiling point of 120°C or higher in an amount of greater than 1% by weight renders the retardation of the drying rate conspicuous while the inclusion of components with a boiling point of 170°C or higher in an amount of greater than 1000 ppm would cause residue to remain on the surface of the cleaned and dried item, so that the application to precision cleaning becomes difficult.

From the viewpoint of inhibiting the inclusion of impurities, it is preferred that the aliphatic saturated hydrocarbon be synthesized directly from a gaseous hydrocarbon.

The precision cleaning method of claim 19 comprises impregnating fibrous matter with the cleaning agent composition of the present invention adapted to exhibit azeotropic or azeotrope-like characteristics

and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand.

As mentioned above, the respective ratios of the aliphatic saturated hydrocarbon and lower alcohol components to the composition are highly stable irrespective of the vaporization or evaporation, so that the cleaning performance of the composition is also highly stable in the present invention. Therefore, when fibrous matter is impregnated with the cleaning agent composition of the present invention and wiping is carried out by hand with the use of impregnated fibrous matter, the cleaning agent composition remaining in the fibrous matter has little change of component ratios irrespective of the evaporation of the cleaning agent composition from the fibrous matter, so that wiping cleaning can be performed while exerting cleaning power which is stable up to the complete drying of the fibrous matter. Examples of fibrous matters to be impregnated with the cleaning agent composition include cloths such as natural fiber cloth, synthetic fiber cloth and nonwoven fabric and papers such as wiping paper.

Effect of The Invention

In the cleaning method of the present invention, use is made of a cleaning agent consisting essentially

of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg. Thus, the cleaning method not only resolves the drawbacks of the conventional hydrocarbon-based cleaning agent such as nonhazardousness to human, smell and poor finishing quality but also does not destroy the ozonosphere because of the absence of chlorine and is free from the danger of environmental pollution attributed to mixing in ground water. Further, the cleaning agent composition has the same power as that of the chlorinated cleaning agent such as freon 113, so that high-quality removal of dirt can be performed from the item.

Further, the use of the cleaning agent of saturated hydrocarbon according to the present invention enables using vapor in an amount which is stable and does not change irrespective of the passage of time, so that high-quality removal of dirt from the item to be cleaned can be performed for a prolonged period of time.

Still further, the performance of the cleaning agent composition of saturated hydrocarbon according to the present invention can be maintained for a prolonged

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period of time by recycling while removing dirt components mixed therein with the use of water, so that the running cost can be held low.

Moreover, the cleaning agent composition comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to exhibit azeotropic or azeotrope-like characteristics not only exerts very excellent dryability and cleaning capability but also enables maintaining low corrosive effect on various materials and excellent composition stability during the cleaning operation and storage.

Further, the cleaning agent composition whose total content of n-hexane, methanol, isopropanol and n-propanol is less than 10% by weight based on all of the composition enables ensuring nonhazardousness to human.

Still further, the cleaning agent composition whose water content is less than 2000 ppm by weight enables suppressing staining and improving cleaning quality.

The cleaning agent composition in which the total amount of components having a boiling point of 120°C or

higher at 760 mmHg is less than 1% by weight and the total amount of components having a boiling point of 170°C or higher at 760 mmHg is less than 1000 ppm by weight enables maintaining extremely low residue and excellent dryability.

In the precision cleaning method comprising impregnating fibrous matter with a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol so as to exhibit azeotropic or azeotrope-like characteristics and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand, the cleaning agent composition has little change of component ratios irrespective of the evaporation of the cleaning agent composition from the fibrous matter, so that wiping cleaning can be performed while maintaining stable cleaning power up to the complete drying of the fibrous matter.

Preferred Embodiment of The Invention

The present invention will now be described in greater detail with reference to the following Examples and Comparative Examples, which should not be construed

as limiting the scope of the invention.

Examples 1 to 8 and Comparative Examples 1 to 4

Examples 1 to 6 are examples of cleaning methods for removing dirt from an item to be cleaned with the use of the cleaning agent of saturated hydrocarbon according to the present invention. Examples 7 and 8 are examples of cleaning methods in which, after dirt removal and before drying, the item is treated with the cleaning agent of saturated hydrocarbon according to the present invention.

A 60 x 70 mm plate of SUS 304 was uniformly coated with 1.0 g of cutting oil Unicut GH-35 (trade name, produced by Nippon Oil Co., Ltd.), thereby obtaining item to be cleaned A. 0.5 g of cutting oil Daphne cut HS-1 (trade name, produced by Idemitsu Kosan Co., Ltd.) was injected in a blind hole of 5 mm in diameter and 6 mm in depth of a SUS 304 block, thereby obtaining item to be cleaned B. The cleaning procedure employed is as shown in Fig. 1. Dirt was removed in the first tank and finishing was conducted in the second tank. The second tank was disposed just before the drying step. In each of the tanks, the cleaning was performed by dipping the item in the cleaning agent held at room temperature for 1 min while applying ultrasonic vibration of 100 W / 40 KHz output. In the drying step,

80°C air was blown to the item for 3 min. In the evaluation of cleaning performance after the drying step, the appearance was visually inspected to find whether or not any stain is present and to find whether or not any liquid remains on the item surface with respect to the dryability. Further, any oil remaining on the item was extracted with trichlene and the absorbance of the extract was measured. The oil removal ratio was calculated from the measurement. Evaluation results are given in Table 1. In the column "removing capability" of Table 1, the mark "o" means an oil removal ratio of over 90%, the mark "Δ" an oil removal ratio of 50 to 90% and the mark "x" an oil removal ratio of less than 50%. In the column "stain" of Table 1, the mark "o" means that stain was not found on the item surface and the mark "x" means that stain was found on the item surface. In Table 1, "PGM-AC" is propylene glycol monomethylacetate (b.p. 143°C) categorized as flash point classification no. 3 of dangerous commodity which was produced by Kuraray Co., Ltd., and "Daphne alpha cleaner H" is cleaning agent of isoparaffinic hydrocarbon (b.p. 210 to 263°C) categorized as flash point classification no. 3 of dangerous commodity which was produced by Idemitsu Kosan Co., Ltd. Table 2 specifies 95% running point and 99% running point

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temperature ranges of each cleaning agent of saturated hydrocarbon employed in Examples 1 to 8.

Referring to Table 1, saturated hydrocarbons were used in both the first and second tanks of Examples 1 to 5. In the examples, the mark "o" was obtained with respect to all of the oil removing capability, appearance and dryability. In Examples 6 to 8, the above high-boiling-point solvents were used in the first tank and saturated hydrocarbons were used in the second tank. In all of Examples 6 to 8, the mark "o" was obtained with respect to all of the oil removing capability, appearance and dryability as shown in Table 1, thereby demonstrating the capability of high-quality finishing.

In Comparative Example 1, use was made of general-purpose "Daphne alpha cleaner H" composed mainly of isoparaffinic hydrocarbon solvent with 14 carbon atoms (b.p. 166 to 202°C categorized as flash point classification no. 3 of dangerous commodity and produced by Idemitsu Kosan Co., Ltd.). Referring to Table 1, the mark "o" was given to the oil removing capability, thereby demonstrating that there was no problem therein. However, the appearance observation showed the presence of stain on the item surface. Further, liquid remained on the item surface. There-

fore, it is seen that the use of hydrocarbon with more than 12 carbon atoms causes problems in dryability and finishing quality. In Comparative Example 2, use was made of the conventional hydrocarbon-based cleaning agent, i.e., kerosene (b.p. 175 to 320°C categorized as flash point classification no. 2 of dangerous commodity). Referring to Table 1, the mark "o" was given to the oil removing capability, thereby demonstrating that there was no problem therein. However, the appearance observation showed the presence of stain on the item surface. Thus, it is apparent that, when the distillation temperature range is broad, finishing quality is deteriorated. Further, kerosene has problems in non-hazardousness to human, stability and smell because unsaturated hydrocarbons and aromatic hydrocarbons are contained therein. In Comparative Example 3, use was made of naphtesol M and, in Comparative Example 4, use was made of ethyl carbitol. Although the mark "o" was given to the oil removing capability in both the comparative examples, thereby demonstrating that there was no problem therein, not only were there stain and liquid residue but also the dryability and finishing quality were poor. Further, there were strong smell problems in both the comparative examples.

Table 1

	No.	Cleaning agent employed		Evaluation				
		1st tank	2nd tank	remov- ing capa- bility		stain		drys- ability
				A	B	A	B	
Exam- ple	1	isooctane (C-8)	isooctane	o	o	o	o	o
	2	isononane (C-9)	isononane	o	o	o	o	o
	3	n-nonane (C-9)	"	o	o	o	o	o
	4	n-decane (C-10)	"	o	o	o	o	o
	5	isododecane (C-12)	"	o	o	o	o	o
	6	ethyl carbitol	n-decane (C-10)	o	o	o	o	o
	7	PGM-AC	isononane (C-9)	o	o	o	o	o
	8	naphtesol M	" (C-9)	o	o	o	o	o
Comp. Ex.	1	Daphne alpha cleaner H	Daphne alpha cleaner H	o	o	x	x	x
	2	kerosene	kerosene	o	o	x	x	x
	3	naphtesol M	naphtesol M	o	o	x	x	x
	4	ethyl carbitol	ethyl carbitol	o	o	x	x	x

Table 2

Satd. hydrocarbon	Running point temp. range	
	95%	99%
isooctane (C=8)	113 - 115	113 - 116
ethylcyclohexane (C=8)	129 - 133	129 - 134
isononane (C=9)	133 - 137	133 - 138
n-nonane (C=9)	150 - 151	150 - 152
n-decane (C=10)	169 - 172	169 - 173
isododecane (C=12)	189 - 194	189 - 169

Example 9

Fig. 2 is a sectional view of the apparatus used in this Example. Numeral 101 denotes a vapor drying tank, and a heater 102 is inserted in its bottom part. The heater 102 is supplied with heat by a steam boiler and the temperature thereof is controlled by means of a pressure regulation valve 104. A chiller coil 105 is provided at an upper part of the vapor drying tank 101, which cools and liquefies the solvent vapor. The liquefied solvent is transferred through a recovery pipe 103 and recovered in a recovery tank 106. The recovery tank 106 separates dewed and mixed water and the solvent freed of water is caused to overflow from

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the recovery tank 106. The overflow portion of the solvent is recycled into the vapor drying tank 101. Numeral 107 denotes a drain.

In this Example, the employed solvent was highly purified isooctane whose initial boiling point, 95% running point and 99% running point were 113°C, 115°C and 116°C, respectively, which was selected from among the saturated hydrocarbons listed in the above Table 2.

The highly purified isooctane was introduced in the vapor drying tank 101 of the above apparatus, and the boiler input steam pressure was set at 1.8 kgf/cm². The heating temperature was 117°C which was satisfactory for vaporizing the highly purified isooctane. Pressed copper parts as items to be cleaned were carried in piled form into vapor zone of the vapor drying tank 101. The vapor was applied to the surface of the pressed parts and the isooctane liquefied by the pressed parts was recovered in the vapor drying tank 101. The pressed parts were taken out 2 min later. Appearance inspection showed that there was no stain adhesion.

In this Example, the vapor drying with the highly purified isooctane enables drying contact portions of the piled parts and further enables performing the above drying by the use of the apparatus of simple

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structure, so that the running cost can be lowered.

Example 10

Fig. 3 shows the structure of the apparatus used in Example 10, a modification of Example 9. Numeral 201 denotes an airtight cleaning tank 201. An item to be cleaned is carried therein and undergoes vapor drying. Then, it is carried out of the same. This airtight cleaning tank 201 has a double structure consisting of an external jacket portion and an inner vapor drying zone. Vapor is passed through the external jacket portion so that the inner vapor drying zone is heated to thereby ensure the complete transfer of vapor heat to the item to be cleaned. A leak valve 218 is connected to the airtight cleaning tank 201, which restores the internal pressure of the tank to atmospheric pressure.

This airtight cleaning tank 201 is connected through a vapor supply valve 203 to a vaporization tank 202. The vaporization tank 202 has its inside provided with a U-shaped heating pipe and heats the solvent to thereby vaporize the same. The vapor supply valve 203 controls the amount of solvent vapor supplied to the item to be cleaned introduced in the airtight cleaning tank 201. After the completion of vapor supply to the item to be cleaned, a pressure reducing valve 204 is

opened and evacuation is executed by means of a vacuum pump 205 so that the item to be cleaned is dried.

A cooler 206 is interposed between the pressure reducing valve 204 and the vacuum pump 205. This cooler 206 cools and liquefies the vapor prior to introduction in the vacuum pump 205. Numeral 207 denotes a solvent recovery tank connected to the vacuum pump 205 and numeral 208 a solvent recovery tank connected to the airtight cleaning tank 201. During the supply of vapor to the item to be cleaned, a valve 209 is opened to thereby enable recovering the liquefied solvent in the solvent recovery tank 208.

Upon the completion of vapor supply, the valve 209 is closed and valves 210 and 211 are opened to thereby recover the solvent in the solvent recovery tank 208. This vaporization tank 202 is provided with a liquid level sensor 212. Upon the detection of lower limit by means of the sensor, a supply pump 213 is operated and a valve 214 is opened to thereby supply the solvent from the solvent recovery tank 207.

In this Example, a liquid ring pump is used as the vacuum pump 205. In the liquid ring pump, the seal of the casing and impeller disposed in the pump is executed by the use of employed solvent, thereby simultaneously carrying out the vacuum retention and the solvent

withdrawal in vacuum. The airtight cleaning tank 201 and the vaporization tank 202 are heated by a steam boiler 215, and this heating is controlled by means of pressure control valves 216 and 217.

In this Example, the employed solvent was highly purified isononane whose initial boiling point, 95% running point and 99% running point were 133°C, 137°C and 138°C, respectively, which was selected from among the saturated hydrocarbons listed in the above Table 2.

The cleaning and drying process of this Example comprised carrying the item to be cleaned in the airtight cleaning tank 201, reduction of the internal pressure of the airtight cleaning tank 201, vapor introduction into the airtight cleaning tank 201, vacuum drying, leak for restoring the internal pressure of the airtight cleaning tank 201 to atmospheric pressure and withdrawal of the cleaned item.

Before starting the operation, the vaporization tank 202 was evacuated to thereby realize the vapor-liquid equilibrium of highly purified isononane. The vacuum pump 205 was operated to thereby reduce the entire internal pressure of the apparatus to 60 mmHg (-700 mmHg). Thereafter, the vapor supply valve 203 and the pressure reducing valve 204 were closed and the leak valve 218 was opened so that the internal pressure

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of the airtight cleaning tank 201 was restored to atmospheric pressure.

The steam boiler 215 was operated to thereby heat the solvent put in the vaporization tank 202. The heating steam pressure was 2.5 kgf/cm^2 . The inside of the vaporization tank 202 was heated so that the vapor pressure was increased to 560 mmHg (-200 mmHg) and held thereat. The liquid temperature was 127°C inside the vaporization tank 202.

This temperature agreed with that of the vapor of highly purified isononane. Thus, the increase of the heating steam pressure raises the pressure and temperature inside the vaporization tank 202 and contrarily the lowering of the heating steam pressure lowers the vapor pressure and temperature thereinside. This means that the heat supply can be changed depending on the thermal conductivity and shape of the item to be cleaned. The airtight cleaning tank 201 was heated with 1.0 kgf/cm^2 input steam. This heating suppresses vapor consumption attributed to the dewing on the inner wall at the time of supply of solvent vapor to the airtight cleaning tank 201 to thereby have the effect of improving the efficiency of heat supply to the item to be cleaned.

Glass lens having undergone the cleaning with a

water-base cleaning agent, rinsing with water, replacement with IPA and dipping in highly purified isononane was carried in the airtight cleaning tank 201. This lens was one prior to coating treatment. The pressure reducing valve 204 was opened to thereby reduce the internal pressure of the airtight cleaning tank 201 to 410 mmHg (-350 mmHg), the pressure reducing valve 204 was closed and the vapor supply valve 203 was opened to thereby supply the vapor of highly purified isononane.

The supply pressure was maintained at 530 mmHg (-230 mmHg) because of the equilibrium between the airtight cleaning tank 201 and the vaporization tank 202 and isononane vapor was supplied to the airtight cleaning tank 201 because vaporization was promoted to restore the pressure dropped in the vaporization tank 202 to regular pressure. The vapor temperature was about 127°C which was identical with that of the liquid disposed in the vaporization tank 202. The vapor of highly purified isononane supplied heat to the lens carried in the airtight cleaning tank 201 to thereby raise the temperature of the lens. This step was executed for 60 sec.

The set period of 60 sec is not particularly limited. When the item to be cleaned is composed of a material of high thermal conductivity such as metals,

the period can be shortened. Further, the amount of vapor supply can be changed by a pressure difference between the airtight cleaning tank 201 and the vaporization tank 202 at the time of vapor supply. However, when the pressure difference is too large, bumping occurs to thereby cause not only vapor but also mist to soar, which becomes a factor detrimental to precision drying. Therefore, the pressure difference between the airtight cleaning tank 201 and the vaporization tank 202 is preferred to range from 100 to 200 mmHg. During that period, the valve 209 was opened to thereby recover liquefied highly purified isononane. After the completion of vapor supply, the valve was closed.

After the passage of given time, the vapor supply valve 203 was closed and the pressure reducing valve 204 was opened to thereby reduce the internal pressure of the airtight cleaning tank 201 to 30 mmHg (-730 mmHg), which was maintained for 90 sec. Thus, the highly purified isononane adhering to the item had its boiling point dropped in accordance with the reduction of the pressure of the atmosphere so that the vaporization was promoted. Thus, rapid drying was effected. After the passage of given time, the pressure reducing valve 204 was closed and the leak valve 218 was opened to thereby restore the internal pressure of the air-

tight cleaning tank 201 to atmospheric pressure. Then, the process was completed. The highly purified isononane present in the solvent recovery tank 207 was recycled to the vaporization tank 202 by opening the valves 209 and 210.

The above process was repeated 50 times. However, the internal pressure of the vaporization tank 202 did not change, so that stable vapor supply was carried out. The stepwise valving program and the change of internal pressure of the airtight cleaning tank 201 are shown in Figs. 4 and 5, respectively. The glass lens had no liquid residue after the drying and presented no quality problem on the drying.

In this Example, the internal pressure of the airtight cleaning tank 201 was reduced only once at the time of vacuum drying of the item to be cleaned. However, the pressure reduction and leak can be repeated a plurality of times. This enables rapidly drying portions whose drying is difficult such as a blind hole and a minute slit.

In this Example, the use of highly purified isononane whose boiling point range is small enables stable vapor supply without the change of the amount of supplied vapor irrespective of the passage of time and also enables clean precision drying free of stain

residue. Further, the liquid composition does not change, so that the frequency of liquid replacement can be reduced to thereby simplify the handling and enable reducing running cost. Still further, the use of a liquid ring pump as the vacuum pump 205 avoids mixing of the solvent into the oil as different from an oil rotation pump and minimizes the leak of inflammable vapor because of the apparatus becoming a closed system to ensure safety.

Example 11

Fig. 6 shows the structure of the apparatus used in Example 11, another modification of Example 9. Numeral 301 denotes an airtight cleaning tank. An item to be cleaned is carried therein and undergoes vapor drying. Then, it is carried out of the same. A leak valve 311 is connected to the airtight cleaning tank 301. Numeral 302 is a vaporization tank, which vaporizes the solvent by an electric heater for indirect solvent heating. Numeral 303 is a vapor supply valve interposed between the airtight cleaning tank 301 and the vaporization tank 302, which controls the amount of solvent vapor supplied to the item to be cleaned introduced in the airtight cleaning tank 301.

After the completion of vapor supply to the item to be cleaned, a pressure reducing valve 304 is opened

and evacuation is executed by means of a vacuum pump 305 so that the item to be cleaned is dried. A cooler 307 cools and liquefies the vapor prior to introduction in the vacuum pump 305. The vaporization tank 302 is provided with a liquid level sensor 310. Upon the detection of lower limit by means of the sensor, control is effected so that a supply pump 308 is operated and a valve 309 is opened. Thus, the solvent is supplied from a separation tank 306 to the vaporization tank 302.

A water ring pump is used as the vacuum pump 305. In the water ring pump, the seal of the casing and impeller disposed in the pump is executed by the use of water. The water ring pump simultaneously discharges water and the solvent toward the separation tank 306. The saturated hydrocarbon used as the solvent is immiscible with water. Hence, separation is made in the separation tank 306 so that the saturated hydrocarbon constitutes the upper layer while water constitutes the lower layer. The water constituting the lower layer is recycled to the pump 305 as the seal water. An oil/water separation filter can be used for promoting the separation into the upper and lower layers.

In this Example, the employed solvent was highly purified n-decane whose initial boiling point, 95%



running point and 99% running point were 169°C, 172°C and 173°C, respectively, which was selected from among the highly purified saturated hydrocarbons listed in the above Table 2.

As a set-up for the operation of the above apparatus, the water ring pump 305 was operated to thereby reduce the entire internal pressure of the apparatus. Thereafter, the vapor supply valve 303 and the pressure reducing valve 304 were closed and the leak valve 311 was opened so that the internal pressure of the airtight cleaning tank 301 was restored to atmospheric pressure. The heater was connected to power source to thereby heat the solvent placed in the vaporization tank 302. The internal pressure of the vaporization tank 302 was so reduced that the inside of the tank was filled with the vapor in an amount corresponding to the vapor pressure at the heating temperature. The temperature of highly purified n-decane present in the vaporization tank 302 was about 160°C while the internal pressure of the vaporization tank 302 was held at 560 mmHg (-200 mmHg).

Polished metal parts having been dipped in the highly purified n-decane after dirt removal were carried in the airtight cleaning tank 301. The pressure reducing valve 304 was opened to thereby reduce the

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internal pressure of the airtight cleaning tank 301 to 410 mmHg (-350 mmHg), the pressure reducing valve 304 was closed and the vapor supply valve 303 was opened to thereby supply the vapor of highly purified n-decane into the airtight cleaning tank 301.

The supply pressure was maintained at 540 mmHg (-220 mmHg), and the vapor was supplied into the airtight cleaning tank 301 by virtue of the pressure difference and the heating of the inside of the vaporization tank 302. The vapor supplied heat to the polished metal parts carried in the airtight cleaning tank 301 to thereby raise the temperature of the polished metal parts. This step was executed for 30 sec.

After the passage of given time, the vapor supply valve 303 was closed and the pressure reducing valve 304 was opened to thereby reduce the internal pressure of the airtight cleaning tank 301 to 30 mmHg (-730 mmHg), which was maintained for 90 sec. Thus, the highly purified n-decane had its boiling point dropped in accordance with the above pressure reduction so that the vaporization was promoted. The heat provided by the vapor supply was utilized for the vaporization heat required to execute the drying.

After the passage of given time, the pressure reducing valve 304 was closed and the leak valve 311

was opened to thereby restore the internal pressure of the airtight cleaning tank 301 to atmospheric pressure. Then, the process was completed. The above process was repeated 20 times. However, the internal pressure of the vaporization tank 302 did not change, so that stable vapor supply was carried out. The polished metal parts had no liquid residue after the drying. Visual inspection thereof showed that there was no staining.

In this Example, the use of highly purified n-decane whose boiling point range is small enables stable vapor supply without the change of the amount of supplied vapor irrespective of the passage of time and also enables clean precision drying free of stain residue. Further, the apparatus is a closed system, so that the leak of inflammable vapor is minimized to thereby ensure safety. Still further, the use of a water ring pump has the effect of being capable of discharging static electricity accumulated in the solvent by means of water.

Each of the following Examples 12 to 18 is an example of the precision cleaning method of the present invention comprising the steps of dipping an optical element to be cleaned in an organic solvent and/or a

water-base cleaning agent to thereby remove dirt, dipping the optical element in water to thereby rinse off the organic solvent and/or water-base cleaning agent adhering to the optical element, dipping the optical element in a hydrophilic solvent to thereby replace the water adhering to the optical element therewith, dipping the optical element in the above cleaning agent of saturated hydrocarbon according to the present invention to thereby replace the hydrophilic solvent adhering to the optical element therewith and drying the optical element to thereby remove the cleaning agent of saturated hydrocarbon from the optical element for finishing.

Example 12

A concavoconvex glass lens of 16 mm in diameter composed of glass material BK7 which had a convex radius of curvature of 46.9 mm and a concave radius of curvature of 9.6 mm was used as an item to be cleaned. Pitch dissolved in trichlene and abrasive used in customary lens polishing were caused to adhere to this glass lens. 100 such dirty glass lenses were set on a three-points supporting jig for lenses as shown in Fig. 10 and each jig was caused to flow through a cleaning line of 12 tanks specified in Table 3. All the tanks were moved at a pitch of 1 min.



Tank nos. 1 and 2 were charged with organic solvent EE-4110 (cleaning agent based on terpenic hydrocarbon, produced by Olympus Optical Co., Ltd.), which was heated at 40°C and provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 3 and 4 were charged with water-base cleaning agent EE-1110 (neutral cleaning agent produced by Olympus Optical Co., Ltd.), which was heated at about 35°C and provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 5 to 7 were charged with pure water of about 1 MΩ in conductivity, which was provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 8 to 10 were charged with hydrophilic solvent IPA, which was provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec.

Tank no. 11 was charged with highly purified isononane having 9 carbon atoms whose 95% running point falls at 4°C from its initial boiling point and whose 99% running point falls at 5°C from its initial boiling point in distillation at 760 mmHg as specified in Table 2, which was provided with oscillation of 100 mm width once/sec only. Tank no. 12 was charged with the same highly purified isononane as in tank no. 11, which was not provided with ultrasonic nor oscillation. The

lifting of the item therefrom was conducted at a velocity as low as 5 mm/sec. In the final drying step, 80°C air cleaned through a filter was blown to the item for 3 min in a drying oven to thereby remove any adhering isononane and conduct dry finishing.

Dried glass lenses were allowed to fully cool and, 20 min later, the post-cleaning evaluation was conducted. In the post-cleaning evaluation, the glass lenses were put under a fluorescent lamp to make reflection and visually inspected. Those free of stain were judged as good items and those with stain judged as defective items. After the completion of the evaluation, all the glass lenses were coated with optical thin films and the post-coating evaluation was conducted. In the post-coating evaluation, the coated glass lenses were put under a fluorescent lamp to make reflection and visually inspected. The evaluation was made on the unevenness or uniformity of the optical thin films.

As a result, both the post-cleaning and post-coating evaluations showed that all the evaluated 100 glass lenses were good items and the defect ratio was 0/100. The results are given in Table 4. Therefore, in this Example, dirt adhering to the precision optical element can be removed to produce high-quality items

without stain.

Examples 13 to 18

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with five varieties of highly purified saturated hydrocarbons having 8 to 12 carbon atoms whose distillation temperature range from the initial boiling point is limited as specified in Table 2.

Evaluation results are given in Table 4. With respect to both the post-cleaning and post-coating evaluations, all the defect ratios were 0/100 in Examples 13 to 15 and 18 as in Example 12, thereby ensuring apparent superiority to the following comparative example results. In Example 16, the defect ratio was 1/100 with respect to the post-coating evaluation although being 0/100 with respect to the post-cleaning evaluation. However, these show significant superiority to the following comparative example results. In Example 17, the defect ratio was 1/100 with respect to the post-cleaning evaluation and 3/100 with respect to the post-coating evaluation. However, also, these show significant superiority to the following comparative example results. Therefore, in these Examples, dirt adhering to the precision optical element can be removed to produce high-quality items without stain.



Comparative Example 5

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with isononane having 9 carbon atoms whose 95% running point and 99% running point were 8°C and 19°C from the initial boiling point, respectively, in distillation as indicated in Table 5. This isononane had large distillation temperature range and thus its purity was low. Evaluation results are given in Table 4. The defect ratio was as high as 13/100 with respect to the post-cleaning evaluation and as high as 25/100 with respect to the post-coating evaluation. Although the drying velocity was high without any disadvantage, the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.

Comparative Example 6

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with isododecane having 12 carbon atoms whose 95% running point and 99% running point were 7°C and 12°C from the initial boiling point, respectively, in distillation as indicated in Table 5. Evaluation results are given in Table 4. The defect ratio was as

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high as 42/100 with respect to the post-cleaning evaluation and as high as 56/100 with respect to the post-coating evaluation. Although the drying velocity was high without any disadvantage, the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.

Comparative Example 7

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with n-tridecane having 13 carbon atoms whose 95% running point and 99% running point were 38°C and 48°C from the initial boiling point, respectively, in distillation as indicated in Table 5. Evaluation results are given in Table 4. The defect ratio was as high as 65/100 with respect to the post-cleaning evaluation and as high as 82/100 with respect to the post-coating evaluation. The drying velocity was relatively low, and the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.

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Table 3

Tank	No.1-2	No.3-4	No.5-7	No.8-10	No.11	No.12
Type	org. solvent	water-base cleaning agent	water	hydrophilic solvent	highly purified satd. hydrocarbon	
Liq. name	EE-4110	EE-1110	pure water	IPA	iso-nonane	iso-nonane
Condition	40°C 1 min. oscillated, ultra-sonic applied	35°C 1 min. oscillated, ultra-sonic applied	20°C 1 min. oscillated, ultra-sonic applied	20°C 1 min. oscillated, ultra-sonic applied	15°C 1 min. oscillated	15°C 1 min. lifted at low velocity

Table 4

	Liq. used in tank nos. 11-12		Evaluation Result	
			post-cleaning evaluation	post-coating evaluation
Example	12	highly purified isononane (C=9)	0/100	0/100
	13	highly purified isooctane (C=8)	0/100	0/100
	14	highly purified ethylcyclohexane (C=8)	0/100	0/100
	15	highly purified n-nonane (C=9)	0/100	0/100
	16	highly purified n-decane (C=10)	0/100	1/100
	17	highly purified isododecane (C=12)	1/100	3/100
	18	highly purified isononane (C=9)	0/100	0/100
Comp. Ex.	5	isononane (C=9)	13/100	25/100
	6	isododecane (C=12)	42/100	56/100
	7	n-tridecane (C=13)	65/100	82/100

Table 5

	Liq.: used in tank nos. 11-12	Distillation character- istic		Flash point (°C)
		95% running point	99% running point	
Comp. Ex.	1 isononane (C=9)	131 - 139	131 - 150	24
	2 isododecane (C=12)	189 - 196	189 - 201	64
	3 n-tridecane (C=13)	212 - 250	212 - 260	86

Example 19

A hydrocarbon mixture consisting of 60.1% by weight of 2-methylpentane, 36.2% by weight of 3-methylpentane and 3.7% by weight of n-hexane was used as the aliphatic saturated hydrocarbon with 6 carbon atoms. A lower alcohol mixture consisting of 85.5% by weight of ethanol, 4.9% by weight of isopropanol and 9.6% by weight of n-propanol was used as the lower alcohol with 1 to 3 carbon atoms. The hydrocarbon mixture and the lower alcohol mixture were mixed together in varied proportions (lower alcohol mixture component ratio: 0, 10, 15, 20, 30 and 100% by weight in Table 7) to thereby obtain mixture compositions in an amount of 200 g each. These compositions were subjected to simple distillation at atmospheric pressure, and the boiling point of initial distillate, initial distillate composition component ratio (hereinafter referred to as "component ratio of vapor phase") and

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component ratio of mixture composition present in the distillation still at the time of having obtained the initial distillate composition (hereinafter referred to as "component ratio of liquid phase") were measured. The results are given in Table 7. The above initial distillate composition is a distillate composition harvested when the boiling point rise has been stabilized after the start of outflow of distillate.

Table 7

b.p. (°C)	62.0	55.5	55.0	55.1	55.3	78.5
Lower alcohol mixt. component ratio (wt.%) of liq. phase	0.0	9.6	15.1	20.8	31.8	100.0
Lower alcohol mixt. component ratio (wt.%) of vapor phase	0.0	15.7	16.1	16.5	16.7	100.0

Referring to Table 7, the boiling point of the mixture composition ranged from 55.0 to 55.5°C when the lower alcohol mixture (consisting of 85.5% by weight of ethanol, 4.9% by weight of isopropanol and 9.6% by weight of n-propanol) component ratio of liquid phase ranged from 9.6 to 31.8% by weight (corresponding to ethanol: 8.5 to 27.2% by weight, isopropanol: 0.4 to 1.6% by weight and n-propanol: 0.9 to 3.1% by weight) and when the hydrocarbon mixture (consisting of 60.1%

by weight of 2-methylpentane, 36.2% by weight of 3-methylpentane and 3.7% by weight of n-hexane) component ratio of liquid phase ranged from 90.4 to 68.2% by weight (corresponding to 2-methylpentane: 54.3 to 40% by weight, 3-methylpentane: 32.7 to 24.7% by weight and n-hexane: 3.3 to 2.5% by weight). The above boiling point is conspicuously lower than both of the boiling point of the hydrocarbon mixture only, 62.0°C, and the boiling point of the lower alcohol mixture only, 78.5°C, thereby exhibiting a conspicuous boiling point lowering phenomenon and demonstrating the realization of approximately azeotropic state. The realization of boiling point lowering enabled providing the cleaning agent composition with very excellent dryability.

A vapor-liquid equilibrium diagram (X-Y diagram) with respect to mixtures of the hydrocarbon mixture and the lower alcohol mixture was drawn on the basis of the results of Table 7, in which the X-axis (axis of abscissa) represented the lower alcohol mixture component ratio of liquid phase and the Y-axis (axis of ordinates) represented the lower alcohol mixture component ratio of vapor phase, and the azeotropic composition was determined. The X-Y diagram is shown in Fig. 7. In the azeotropic state, the component ratio of liquid phase and the component ratio of vapor phase are iden-

tical with each other, so that the intersection of the X-Y diagram and the function $Y = X$ represents an azeotropic composition. Therefore, an azeotropic composition was determined from the X-Y diagram of Fig. 7, which was found to consist of 16.1% by weight of the lower alcohol mixture component and 83.9% by weight of the hydrocarbon mixture component. Accordingly, specifically, it was found that the azeotropic composition consisted of 50.4% by weight of 2-methylpentane, 30.4% by weight of 3-methylpentane, 3.1% by weight of n-hexane, 13.7% by weight of ethanol, 0.8% by weight of isopropanol and 1.6% by weight of n-propanol.

100 g of a cleaning agent composition of the above azeotropic composition was prepared and simple distillation thereof was carried out at atmospheric pressure. Distillate and bottoms (liquid phase) were simultaneously harvested at time intervals, and the composition change thereof was measured. The component ratios were determined by gas chromatography with the use of calibration curve. Gas chromatography was conducted with the use of gas chromatograph GC-14B manufactured by Shimadzu Corporation, column DB-1 (inner diameter: 0.53 mm and length: 30 m) manufactured by Hewlett Packard and detector FID under the conditions such that injection hole temperature: 210°C, detector temperature:

230°C, initial column temperature: 40°C (hold time: 2.5 min), column temperature rise rate: 10°C/min and finally reached column temperature: 200°C. The results are given in Tables 8 and 9. Table 8 shows the relationship between distillate sampling timing and the analytical result of each component ratio along with total lower alcohol and hydrocarbon component ratios (% by weight). On the other hand, Table 9 shows the relationship between bottoms (liquid phase) sampling timing and the analytical result of each component ratio along with total lower alcohol and hydrocarbon component ratios (% by weight). The distillate composition change was in the range of 0.4% by weight only until the end of the distillation, and the composition change of bottoms harvested simultaneously with the distillate was in the range of 4.7% by weight until the end of the distillation. Thus, very excellent composition stability was confirmed.

Table 8

	before distilla- tion	distilla- tion 1	distilla- tion 2	distilla- tion 3	end of distilla- tion
ethanol	13.7	14.9	14.0	13.6	13.2
isopropanol	0.8	0.5	0.7	0.8	1.0
n-propanol	1.6	0.5	1.0	1.4	1.8
2-methylpentane	50.4	52.4	50.6	49.5	48.1
3-methylpentane	30.4	29.4	30.9	31.6	32.4
n-hexane	3.1	2.2	2.8	3.1	3.5
lower alcohol mixture	16.1	15.9	15.7	15.8	16.0
hydrocarbon mixture	83.9	84.1	84.3	84.2	84.0

Table 9

	before distilla- tion	liq. phase 1	liq. phase 2	liq. phase 3	end of liq. phase
ethanol	13.7	13.7	13.4	13.1	13.4
isopropanol	0.8	0.9	1.0	1.3	1.7
n-propanol	1.6	1.7	2.3	3.5	5.7
2-methylpentane	50.4	49.5	48.1	45.9	42.3
3-methylpentane	30.4	31.2	31.8	32.4	32.6
n-hexane	3.1	3.0	3.4	3.8	4.3
lower alcohol mixture	16.1	16.3	16.7	17.9	20.8
hydrocarbon mixture	83.9	83.7	83.3	82.1	79.2

Example 20

A hydrocarbon mixture consisting of 97.3% by weight of 2-methylpentane and 2.7% by weight of n-

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hexane was used as the aliphatic saturated hydrocarbon with 6 carbon atoms. A lower alcohol mixture consisting of 100% by weight of ethanol was used as the lower alcohol with 1 to 3 carbon atoms. The hydrocarbon mixture and the lower alcohol mixture were mixed together in varied proportions (lower alcohol mixture component ratio: 0, 10, 15, 20, 35 and 100% by weight in Table 10) to thereby obtain mixture compositions in an amount of 200 g each. These compositions were subjected to simple distillation at atmospheric pressure, and the boiling point of initial distillate, component ratio of vapor phase and component ratio of liquid phase were measured. The results are given in Table 10.

Table 10

b.p. (°C)	60.5	53.5	53.3	53.7	54.0	78.3
Lower alcohol mixt. component ratio (wt.%) of liq. phase	0.0	9.6	15.2	20.6	34.0	100.0
Lower alcohol mixt. component ratio (wt.%) of vapor phase	0.0	16.4	16.5	16.8	16.4	100.0

Referring to Table 10, the boiling point of the mixture composition ranged from 53.4 to 54.0°C when the lower alcohol mixture (consisting of 100% by weight of

ethanol) component ratio of liquid phase ranged from 9.6 to 34.0% by weight. The above boiling point is conspicuously lower than both of the boiling point of the hydrocarbon mixture only, 60.5°C, and the boiling point of the lower alcohol mixture only, 78.3°C, thereby exhibiting a conspicuous boiling point lowering phenomenon and demonstrating the realization of approximately azeotropic state. A vapor-liquid equilibrium diagram (X-Y diagram) with respect to mixtures of the hydrocarbon mixture and the lower alcohol mixture was drawn on the basis of the results of Table 10, in which the X-axis (axis of abscissa) represented the lower alcohol mixture component ratio of liquid phase and the Y-axis (axis of ordinates) represented the lower alcohol mixture component ratio of vapor phase, and the azeotropic composition was determined. The X-Y diagram is shown in Fig. 8. An azeotropic composition was determined from the X-Y diagram of Fig. 8, which was found to consist of 16.6% by weight of the lower alcohol mixture component and 83.4% by weight of the hydrocarbon mixture component. Accordingly, specifically, it was found that the azeotropic composition consisted of 81.2% by weight of 2-methylpentane, 2.2% by weight of n-hexane and 16.6% by weight of ethanol.

Example 21

400 g of a mixture consisting of 13.9% by weight of ethanol, 0.8% by weight of isopropanol, 1.6% by weight of n-propanol, 50.3% by weight of 2-methylpentane, 30.4% by weight of 3-methylpentane and 3.1% by weight of n-hexane was put in a distillation flask and distilled at atmospheric pressure by the use of a rectifying column having a theoretical plate number of 25 packed with coiled packing of SUS 306 (Helipack manufactured by Tokyo Special Wire Netting Co., Ltd.). Thus, a distillate of 53.0°C in boiling point was obtained. This distillate was analyzed by the same gas chromatography as in Example 19 with the use of calibration curve and was found to consist of 16.0% by weight of ethanol, 55.4% by weight of 2-methylpentane, 27.9% by weight of 3-methylpentane and 0.7% by weight of n-hexane. This composition had a boiling point lower than those of the components thereof, attesting to the formation of an azeotropic composition.

Example 22

The same hydrocarbon mixture and lower alcohol mixture as in Example 19 were mixed together in varied proportions (lower alcohol mixture component ratio: 5, 10, 15, 20, 30 and 40% by weight in Table 11) to thereby obtain mixture compositions in an amount of 200 g

each. On the other hand, specimens were prepared by applying finger sebum to a slide glass and allowing it to stand still at ordinary temperature and humidity for 24 hr and also by dipping slide glass pieces in an oil marking ink and a solution obtained by dissolving 40% by weight rosin oil in 1,1,1-trichloroethylene as a solvent, respectively, and evaporating the solvent from the dipped slide glass pieces. Hand wiping cleaning of the specimens was performed with the use of wiping paper (Kimwipe produced by Jujo Kimberley) impregnated with the above mixture compositions of varied component ratios. Cleaning performance was evaluated and the criterion therefor was such that:

- o: dirt was completely removed by less than 10 hand wipes,
- Δ: dirt was removed by at least 10 hand wipes, and
- x: dirt was not removed irrespective of at least 10 hand wipes.

The results are given in Table 11. When the lower alcohol mixture component ratio is decreased to 10% by weight, the removal of any of finger sebum, marking ink and rosin oil tends to be difficult. When the lower alcohol mixture component ratio is less than 10% by weight, it occurs that marking ink and rosin oil cannot be removed.

Table 11

Lower alcohol mixture component ratio (wt.%)	5	10	15	20	30	40
finger sebum	Δ	o	o	o	o	o
marking ink	Δ - x	o - Δ	o	o	o	o
rosin oil	x	Δ	o	o	o	o

The cleaning performance of each of the compositions specified in Table 12 was evaluated with respect to various dirt components. The same evaluation was made of a mixture of diethyl ether and ethanol and ethanol as references. With respect to specimens having dirt components adhering thereto, rosin oil and marking ink specimens were prepared in the same manner as described above. Pitch specimen was prepared by dipping a slide glass in a solution obtained by dissolving 40% by weight pitch in 1,1,1-trichloroethylene as a solvent and evaporating the solvent from the dipped slide glass. With respect to epoxy resin, use was made of a specimen prepared by forming an about 0.5 mm thick layer of bisphenol epoxy resin (Epikote produced by Showa Shell Sekiyu K.K.) on a slide glass according to the metal mask printing technique. The cleaning performance was evaluated in the same manner

as described above. The results are given in Table 12. It was confirmed that the compositions 1, 2 and 3 of the present invention exhibit excellent cleaning capability for any of varied dirt components and thus have a very broad range of applicability to dirt.

Table 12

		Compsn. 1	Compsn. 2	Compsn. 3	Mixt. of diethyl ether & ethanol	Ethanol
	2-methylpentane	50.4 wt. %	81.2 wt. %	50.2 wt. %		
	3-methylpentane	30.4 wt. %		30.2 wt. %		
	n-hexane	3.1 wt. %	2.2 wt. %	3.1 wt. %		
	ethanol	13.7 wt. %	16.6 wt. %	14.1 wt. %	20 vol. %	100 wt. %
	methanol			0.2 wt. %		
	isopropanol	0.8 wt. %		2.2 wt. %		
	n-propanol	1.6 wt. %				
	diethyl ether				80 vol. %	
Dirt cleaning capability	pitch	o	o	o	o - Δ	x
	rosin oil	o	o	o	o	o
	lanolin	o	o	o	o - Δ	Δ
	marking ink	o	o	o	o	o
	epoxy resin	o - Δ	o - Δ	o - Δ	o	o

Example 23

The same hydrocarbon mixture and lower alcohol mixture as in Example 19 were mixed together in varied proportions (lower alcohol mixture component ratio: 10, 15, 20, 25, 30, 35, 40 and 50% by weight in Table 13) to thereby obtain mixture compositions. One-minute

dipping test and hand wiping cleaning of each of various materials were performed with the use of the above mixture compositions. Thereafter, the materials were inspected to find any appearance change. The evaluation was made on the criterion such that:

- o: no appearance change was caused by the dipping test and hand wiping,
- A: appearance change was observed only after the dipping test, and
- x: appearance change was observed after not only the dipping test but also the hand wiping.

The results are given in Table 13. Metals and glasses encountered no problems irrespective of the lower alcohol mixture component ratio ranging from 10 to 50% by weight. When the lower alcohol mixture component ratio ranged from 10 to 40% by weight, the thermoplastic resins also encountered no problems. However, PMMA having residual stress attributed to molding occasionally had cracking caused by hand wiping at a lower alcohol mixture component ratio of 35% by weight or higher. The PMMA had slight cracking made by the dipping test but had no appearance change caused by hand wiping at a lower alcohol mixture component ratio of 30% by weight. These showed that the lower alcohol mixture component ratio is required to be less than 35%

by weight and is preferred to be less than 30% by weight for ensuring application of the cleaning agent composition to a wide spectrum of materials of items to be cleaned.

Table 13

Lower alcohol mixt. component ratio (wt.%)	10	15	20	25	30	35	40	50
iron (SPCC)	o	o	o	o	o	o	o	o
copper	o	o	o	o	o	o	o	o
brass	o	o	o	o	o	o	o	o
SUS304	o	o	o	o	o	o	o	o
optical glass BK7	o	o	o	o	o	o	o	o
optical glass SF15	o	o	o	o	o	o	o	o
colorless plate glass	o	o	o	o	o	o	o	o
polyamide (nylon 6)	o	o	o	o	o	o	o	o
PMMA	o	o	o	o	o	o	o	Δ
polycarbonate	o	o	o	o	o	o	o	o
polystyrene	o	o	o	o	o	o	o	Δ
ABS	o	o	o	o	o	o	o	Δ
polyacetal	o	o	o	o	o	o	o	o
PMMA (with residual stress)	o	o	o	o	Δ	x	x	x

Example 24

A hydrocarbon mixture consisting of 60.1% by weight of 2-methylpentane, 36.2% by weight of 3-methylpentane and 3.7% by weight of n-hexane was used as the aliphatic saturated hydrocarbon with 6 carbon atoms. A lower alcohol mixture consisting of 85.5% by

weight of ethanol, 13.4% by weight of isopropanol and 1.1% by weight of methanol was used as the lower alcohol with 1 to 3 carbon atoms. The hydrocarbon mixture and the lower alcohol mixture were mixed together in varied proportions (lower alcohol mixture component ratio: 0, 10, 15, 20, 30 and 100% by weight in Table 14) to thereby obtain mixture compositions in an amount of 200 g each. These compositions were subjected to simple distillation at atmospheric pressure, and the boiling point of initial distillate, component ratio of vapor phase and component ratio of liquid phase were measured. The results are given in Table 14.

Table 14

b.p. (°C)	62.0	54.5	54.2	54.4	54.5	78.5
Lower alcohol mixt. component ratio (wt.%) of liq. phase	0.0	9.8	15.0	20.5	31.6	100.0
Lower alcohol mixt. component ratio (wt.%) of vapor phase	0.0	16.1	16.4	16.7	17.2	100.0

Referring to Table 14, the boiling point of the mixture composition ranged from 54.2 to 54.5°C when the lower alcohol mixture (consisting of 85.5% by weight of ethanol, 13.4% by weight of isopropanol and 1.1% by weight of methanol) component ratio of liquid phase ranged from 9.8 to 31.6% by weight. The above boiling

point is conspicuously lower than both of the boiling point of the hydrocarbon mixture only, 62.0°C , and the boiling point of the lower alcohol mixture only, 78.5°C , thereby exhibiting a conspicuous boiling point lowering phenomenon and demonstrating the realization of approximately azeotropic state. A vapor-liquid equilibrium diagram (X-Y diagram) with respect to mixtures of the hydrocarbon mixture and the lower alcohol mixture was drawn on the basis of the results of Table 14, in which the X-axis (axis of abscissa) represented the lower alcohol mixture component ratio of liquid phase and the Y-axis (axis of ordinates) represented the lower alcohol mixture component ratio of vapor phase, and the azeotropic composition was determined. The X-Y diagram is shown in Fig. 9. In the azeotropic state, the component ratio of liquid phase and the component ratio of vapor phase are identical with each other, so that the intersection of the X-Y diagram and the function $Y = X$ represents an azeotropic composition. Therefore, an azeotropic composition was determined from the X-Y diagram of Fig. 9, which was found to consist of 16.4% by weight of the lower alcohol mixture component and 83.6% by weight of the hydrocarbon mixture component. Accordingly, specifically, it was found that the azeotropic composition

consisted of 49.5% by weight of 2-methylpentane, 31.2% by weight of 3-methylpentane, 2.9% by weight of n-hexane, 14.0% by weight of ethanol, 2.2% by weight of isopropanol and 0.2% by weight of methanol.

100 g of a cleaning agent composition of the above azeotropic composition was prepared and simple distillation thereof was carried out at atmospheric pressure. Distillate and bottoms (liquid phase) were simultaneously harvested at time intervals, and the composition change thereof was measured. The component ratios were determined by gas chromatography with the use of calibration curve. Gas chromatography was conducted in the same manner as in Example 19. The results are given in Tables 15 and 16. Table 15 shows the relationship between distillate sampling timing and the analytical result of each component ratio along with total lower alcohol and hydrocarbon component ratios (% by weight). On the other hand, Table 16 shows the relationship between bottoms (liquid phase) sampling timing and the analytical result of each component ratio along with total lower alcohol and hydrocarbon component ratios (% by weight). With respect to the lower alcohol mixture and hydrocarbon mixture components, the distillate composition change from before the distillation to the end of the distillation was 0.6% by weight and the

composition change of bottoms harvested simultaneously with the distillate was 3.8% by weight until the end of the distillation. Thus, very excellent composition stability was confirmed.

Table 15

	Feedstock liq.	Initial stage of distillation	Middle stage of distillation	Final stage of distillation	End of distillation
ethanol	14.0	14.6	14.4	14.2	14.0
isopropanol	2.2	1.4	1.8	2.2	3.0
methanol	0.2	0.3	0.2	0.1	0.0
2-methylpentane	49.5	51.4	50.2	49.0	46.7
3-methylpentane	31.2	29.9	30.7	31.5	32.7
n-hexane	2.9	2.4	2.7	3.0	3.6
lower alcohol mixt. total	16.4	16.3	16.4	16.5	17.0
hydrocarbon mixt. total	83.6	83.7	83.6	83.5	83.0

Table 16

	Feedstock liq.	Initial stage of distillation	Middle stage of distillation	Final stage of distillation	End of distillation
ethanol	14.0	14.0	14.1	13.9	14.7
isopropanol	2.2	2.3	2.6	3.1	5.5
methanol	0.2	0.1	0.1	0.1	0.0
2-methylpentane	49.5	49.1	48.2	46.9	41.7
3-methylpentane	31.2	31.5	31.8	32.5	33.6
n-hexane	2.9	3.0	3.2	3.6	4.5
lower alcohol mixt. total	16.4	16.4	16.8	17.1	20.2
hydrocarbon mixt. total	83.6	83.6	83.2	82.9	79.8

Examples 25 to 33

400 g of a mixture of component ratios specified as "liquid before distillation" in each of Tables 17 to 25 was put in a distillation flask and distilled at atmospheric pressure by the use of a rectifying column having a theoretical plate number of 25 packed with coiled packing of SUS 306 (Helipack manufactured by Tokyo Special Wire Netting Co., Ltd.). Thus, distillates of component ratios specified in Tables 17 to 25 were obtained at time intervals. The Tables show the relationship between distillate sampling timings and the respective boiling point measurements and analytical results of component ratios along with total lower alcohol and hydrocarbon component ratios (% by weight). The component ratios were analyzed by the same gas chromatography as in Example 19 with the use of calibration curve. The component ratio change was slight and, especially, the changes of lower alcohol and hydrocarbon component ratios were extremely slight, attesting to the formation of azeotropic or azeotrope-like compositions.

Table 17

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.3	0.0	0.8	1.6	80.5	0.0	2.8	16.8	83.3
Initial disti- llate	52.0	16.4	0.0	0.0	0.0	83.6	0.0	0.0	16.4	83.6
Initial stage of disti- llation	52.0	15.8	0.0	0.0	0.0	84.2	0.0	0.0	15.8	84.2
Middle stage of disti- llation	52.4	15.9	0.0	0.0	0.0	82.8	0.0	1.3	15.9	84.1
Final stage of disti- llation	52.5	15.9	0.0	0.0	0.0	83.2	0.0	0.9	15.9	84.1

Table 18

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.5	0.2	2.3	0.0	80.2	0.0	2.8	17.0	83.0
Initial disti- llate	52.0	14.3	3.3	0.0	0.0	82.4	0.0	0.0	17.6	82.4
Initial stage of disti- llation	52.0	15.2	0.8	0.0	0.0	83.9	0.0	0.1	16.0	84.0
Middle stage of disti- llation	52.4	15.5	0.3	0.2	0.0	82.5	0.0	1.5	16.0	84.0
Final stage of disti- llation	52.5	15.3	0.3	0.4	0.0	82.5	0.0	1.5	16.0	84.0

Table 19

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.1	0.2	2.2	0.0	49.7	30.6	3.2	16.5	83.5
Initial disti- llate	52.5	14.2	2.2	0.0	0.0	67.2	16.3	0.1	16.4	83.6
Initial stage of disti- llation	52.5	15.4	0.6	0.0	0.0	62.2	21.6	0.2	16.0	84.0
Middle stage of disti- llation	53.0	15.9	0.3	0.1	0.0	53.4	28.4	1.9	16.3	83.7
Final stage of disti- llation	53.4	15.4	0.2	0.7	0.0	52.8	28.8	2.1	16.3	83.7

Table 20

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.1	0.0	0.8	1.6	51.7	31.8	0.0	16.5	83.5
Initial disti- llate	52.5	15.6	0.0	0.0	0.0	67.1	17.3	0.0	15.6	84.4
Initial stage of disti- llation	52.5	15.9	0.0	0.0	0.0	61.1	23.1	0.0	15.9	84.2
Middle stage of disti- llation	53.0	15.8	0.0	0.3	0.0	54.5	29.4	0.0	16.1	83.9
Final stage of disti- llation	53.0	15.8	0.0	0.3	0.0	54.2	29.7	0.0	16.1	83.9

Table 21

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.1	0.2	2.2	0.0	51.7	31.8	0.0	16.5	83.5
Initial disti- llate	52.5	14.6	1.6	0.0	0.0	67.6	16.2	0.0	16.2	83.8
Initial stage of disti- llation	52.5	15.5	0.6	0.0	0.0	61.2	22.8	0.0	16.1	84.0
Middle stage of disti- llation	53.0	15.5	0.3	0.4	0.0	54.7	29.1	0.0	16.2	83.8
Final stage of disti- llation	53.1	15.5	0.1	0.5	0.0	54.7	29.2	0.0	16.1	83.9

Table 22

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.4	0.0	0.9	1.7	72.4	10.6	0.0	17.0	83.0
Initial disti- llate	52.5	16.2	0.0	0.0	0.0	78.9	4.9	0.0	16.2	83.9
Initial stage of disti- llation	52.5	15.7	0.0	0.0	0.0	78.6	5.7	0.0	15.7	84.3
Middle stage of disti- llation	52.5	16.0	0.0	0.0	0.0	75.6	8.4	0.0	16.0	84.0
Final stage of disti- llation	52.5	16.0	0.0	0.0	0.0	76.0	8.0	0.0	16.0	84.0

Table 23

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.3	0.2	2.2	0.0	83.3	0.0	0.0	16.7	83.3
Initial disti- llate	52.0	10.2	2.7	0.0	0.0	87.1	0.0	0.0	12.9	87.1
Initial stage of disti- llation	52.0	15.5	0.9	0.0	0.0	83.6	0.0	0.0	16.4	83.6
Middle stage of disti- llation	52.0	15.5	0.0	0.1	0.0	84.4	0.0	0.0	15.6	84.4
Final stage of disti- llation	52.1	15.9	0.0	0.0	0.0	84.2	0.0	0.0	15.9	84.2

Table 24

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	14.2	0.0	0.8	1.6	83.4	0.0	0.0	16.6	83.4
Initial disti- llate	52.0	16.6	0.0	0.0	0.0	83.5	0.0	0.0	16.6	83.5
Initial stage of disti- llation	52.0	15.7	0.0	0.0	0.0	84.3	0.0	0.0	15.7	84.3
Final stage of disti- llation	52.0	16.3	0.0	0.0	0.0	83.8	0.0	0.0	16.3	83.8

Table 25

	measured b.p. (°C)	ethanol	methanol	iso- propanol	n- propanol	2-methyl- pentane	3-methyl- pentane	n- hexane	lower alcohol mixt. total	hydro- carbon mixt. total
Liq. before disti- llation	-	13.1	0.0	0.8	1.5	51.8	29.6	3.2	15.4	84.6
Initial disti- llate	52.6	14.0	0.0	0.0	0.0	69.1	16.7	0.2	14.0	86.0
Initial stage of disti- llation	52.6	15.9	0.0	0.0	0.0	59.1	24.4	0.6	15.9	84.1
Middle stage of disti- llation 1	53.0	16.0	0.0	0.2	0.0	53.5	28.1	2.2	16.2	83.8
Middle stage of disti- llation 2	53.5	15.3	0.0	0.5	0.2	52.9	28.7	2.4	16.0	84.0
Middle stage of disti- llation 3	53.5	15.4	0.0	0.6	0.1	52.2	29.2	2.5	16.1	83.9
Final stage of disti- llation	53.5	15.3	0.0	0.8	0.1	50.5	30.5	2.8	16.2	83.8



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What is claimed is:

1. A precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg._____
2. The precision cleaning method according to claim 1, which further comprises treating the cleaning agent used in dirt removal with water so that impurities mixed into the cleaning agent are separated off.
3. The precision cleaning method according to claim 1, wherein the saturated hydrocarbon is an iso-paraffin.
4. The precision cleaning method according to claim 1, wherein the saturated hydrocarbon is principally composed of isononane having 9 carbon atoms.
5. A precision cleaning method comprising vaporizing a cleaning agent consisting essentially of at

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least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg and applying the vapor to an item to be cleaned so that the item to be cleaned is freed of dirt and/or dried.

6. The precision cleaning method according to claim 5, wherein the item to be cleaned is carried in a cleaning treatment chamber, the cleaning treatment chamber has its internal pressure reduced to thereby introduce therein the vapor of the cleaning agent so that the item to be cleaned is freed of dirt and/or dried and the pressure of the cleaning treatment chamber is restored to atmospheric pressure.

7. A precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent, replacing part of the cleaning agent adhering to the item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further treated with a cleaning agent consisting essentially of at least one saturated hydrocarbon

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having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg.

8. The precision cleaning method according to claim 7, wherein the saturated hydrocarbon is an isoparaffin.

9. The precision cleaning method according to claim 7, wherein the saturated hydrocarbon is principally composed of isononane having 9 carbon atoms.

10. The precision cleaning method according to claim 7, wherein, after the replacement and before the drying, the item is dipped in said cleaning agent consisting essentially of at least one saturated hydrocarbon and lifted at a rate of not greater than 70 mm/s from the cleaning agent to thereby depart from its liquid level.

11. A precision cleaning method comprising the steps of dipping an optical element to be cleaned in an organic solvent and/or a water-base cleaning agent to thereby remove dirt, dipping the optical element in

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water to thereby rinse off the organic solvent and/or water-base cleaning agent adhering to the optical element, dipping the optical element in a hydrophilic solvent to thereby replace the water adhering to the optical element therewith, dipping the optical element in a water insoluble solvent to thereby replace the hydrophilic solvent adhering to the optical element therewith and drying the optical element to thereby remove the water insoluble solvent from the optical element for finishing, wherein the water insoluble solvent consists essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg.

12. The precision cleaning method according to claim 11, wherein the saturated hydrocarbon is an isoparaffin.

13. The precision cleaning method according to claim 11, wherein the saturated hydrocarbon is composed of isononane having 9 carbon atoms.

14. The precision cleaning method according to

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claim 11, wherein the water insoluble solvent is treated with water after use in the hydrophilic solvent replacement so that the hydrophilic solvent is separated off from the water insoluble solvent to thereby regenerate the water insoluble solvent.

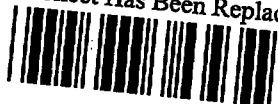
15. A cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics.

16. The cleaning agent composition for hand wiping according to claim 15, whose total content of n-hexane, methanol, isopropanol and n-propanol is less than 10% by weight based on all of the composition.

17. The cleaning agent composition for hand wiping according to claim 15 or 16, whose water content is less than 2000 ppm by weight.

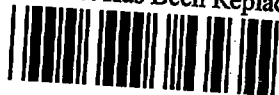
18. The cleaning agent composition for hand

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wiping according to any of claims 15 to 17, wherein the total amount of components having a boiling point of 120°C or higher at 760 mmHg is less than 1% by weight and the total amount of components having a boiling point of 170°C or higher at 760 mmHg is less than 1000 ppm by weight.

19. A precision cleaning method comprising impregnating fibrous matter with a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol so as to exhibit azeotropic or azeotrope-like characteristics and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand.

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ABSTRACT OF THE DISCLOSURE
CLEANING AGENT COMPOSITION AND PRECISION CLEANING
METHOD

Optical elements and other items are cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% running point falls within 5°C of its initial boiling point and whose 99% running point falls within 10°C of its initial boiling point in distillation at 760 mmHg or with the use of a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics. The above cleaning is advantageous from the viewpoint of nonhazardousness to human, smell, dirt removal, quality finishing, running cost and environmental protection.

FIG. 1

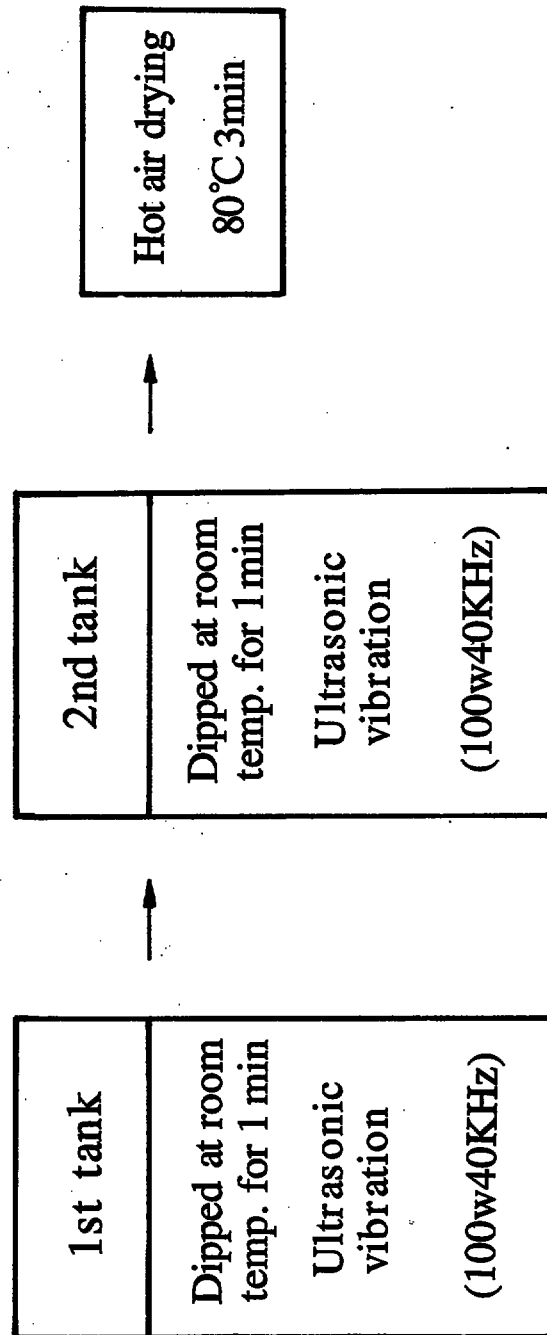


FIG. 2

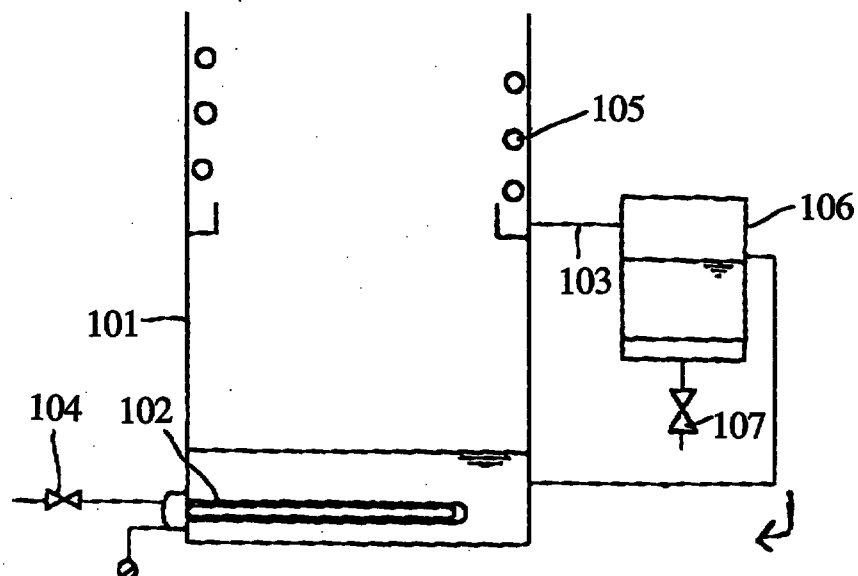


FIG. 3

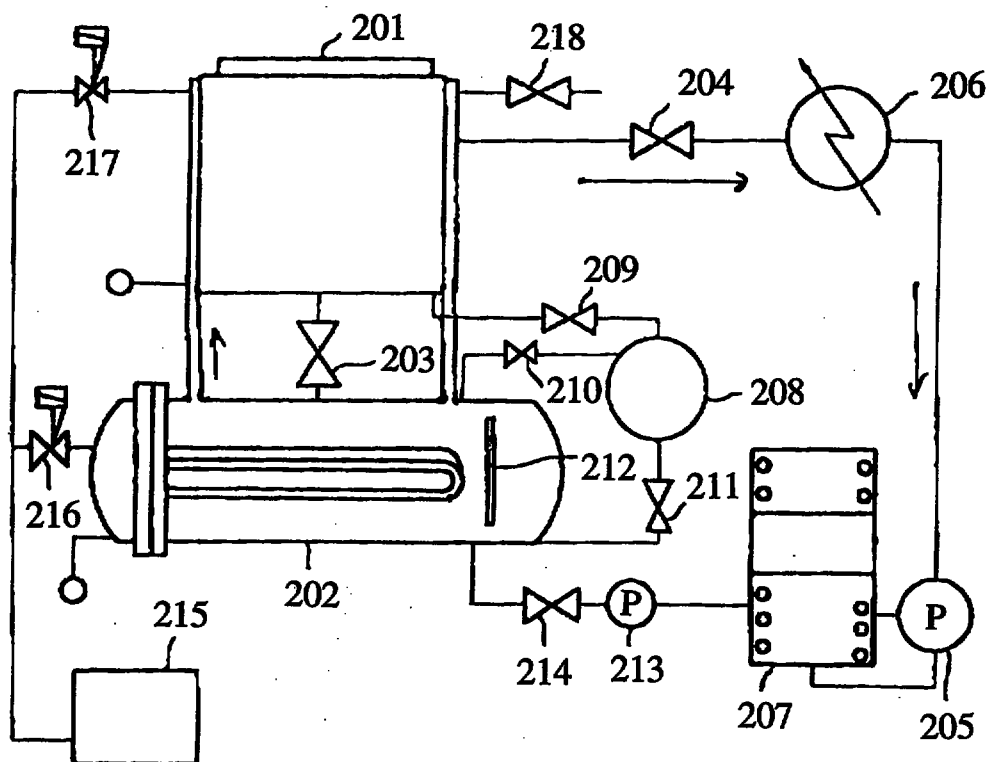


FIG. 4

Valving program

Valve name	Steps			
	Pressure reduction	Vapor introduction	Vac. drying	Leak
203 Vapor supply valve				
204 Pressure reducing valve				
209 Solvent recovery valve				
210 Valve				
211 Valve				
218 Leak valve				

FIG. 5

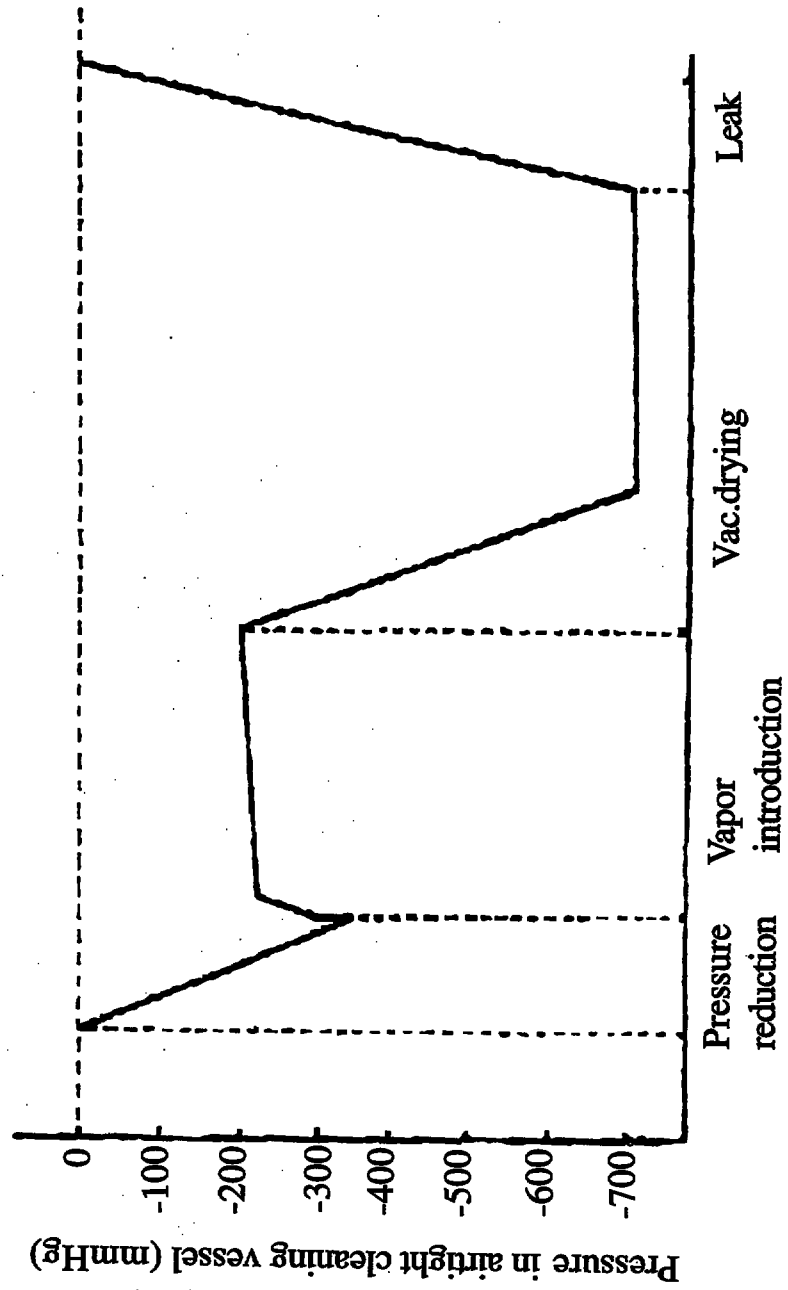


FIG. 6

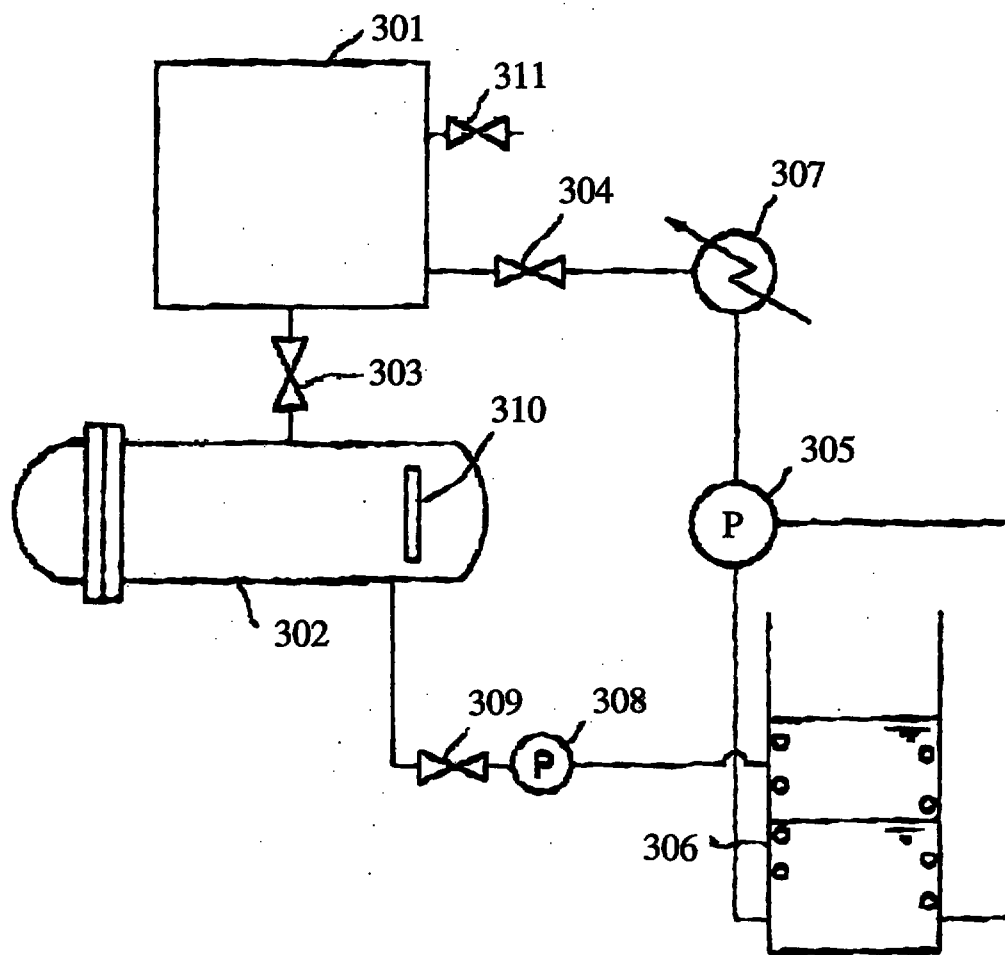


FIG. 7

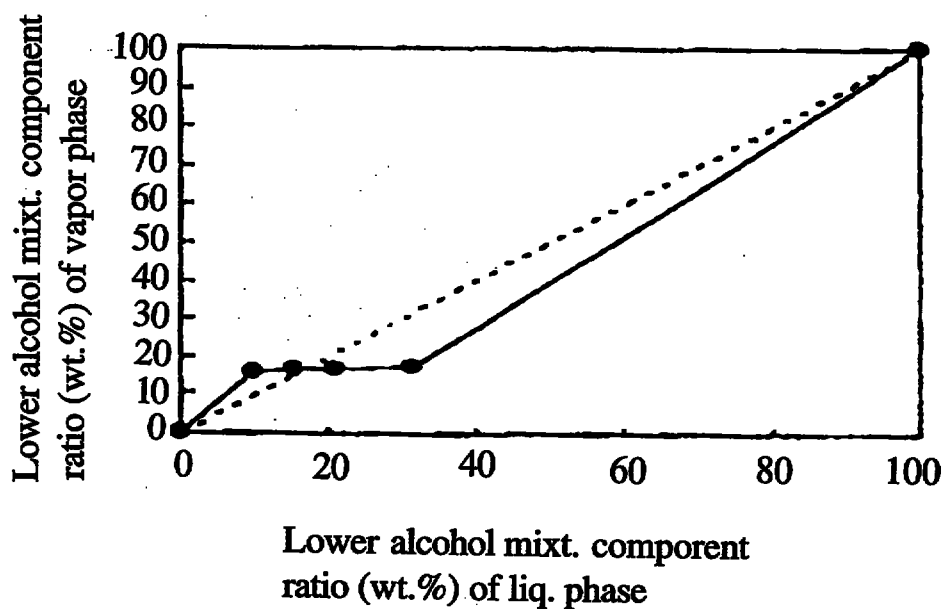


FIG. 8

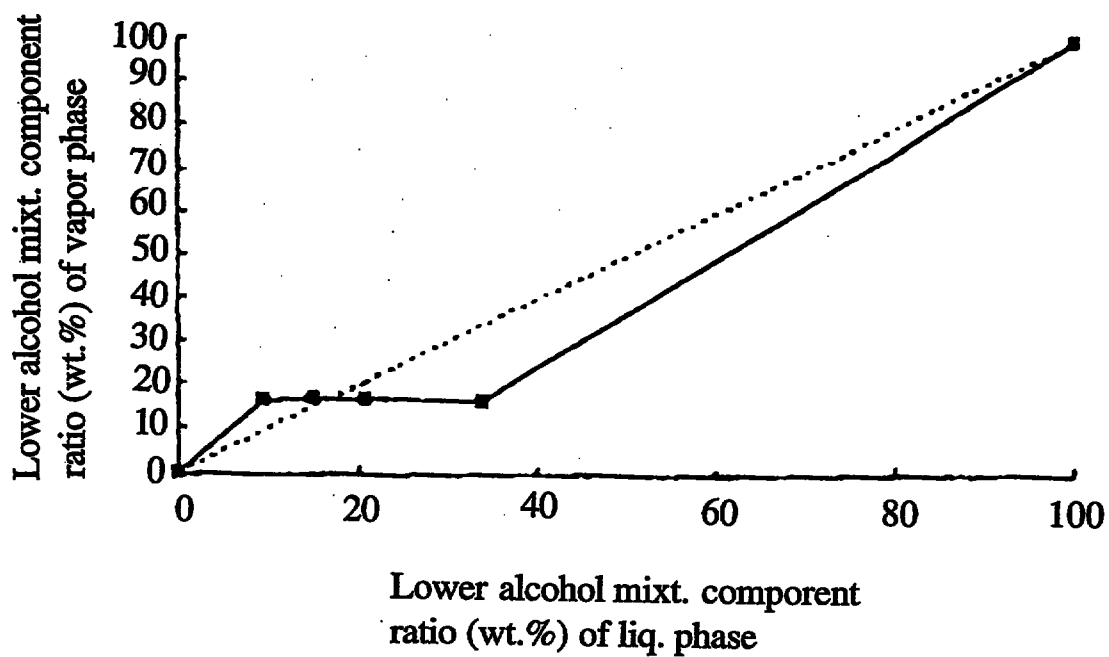


FIG. 9

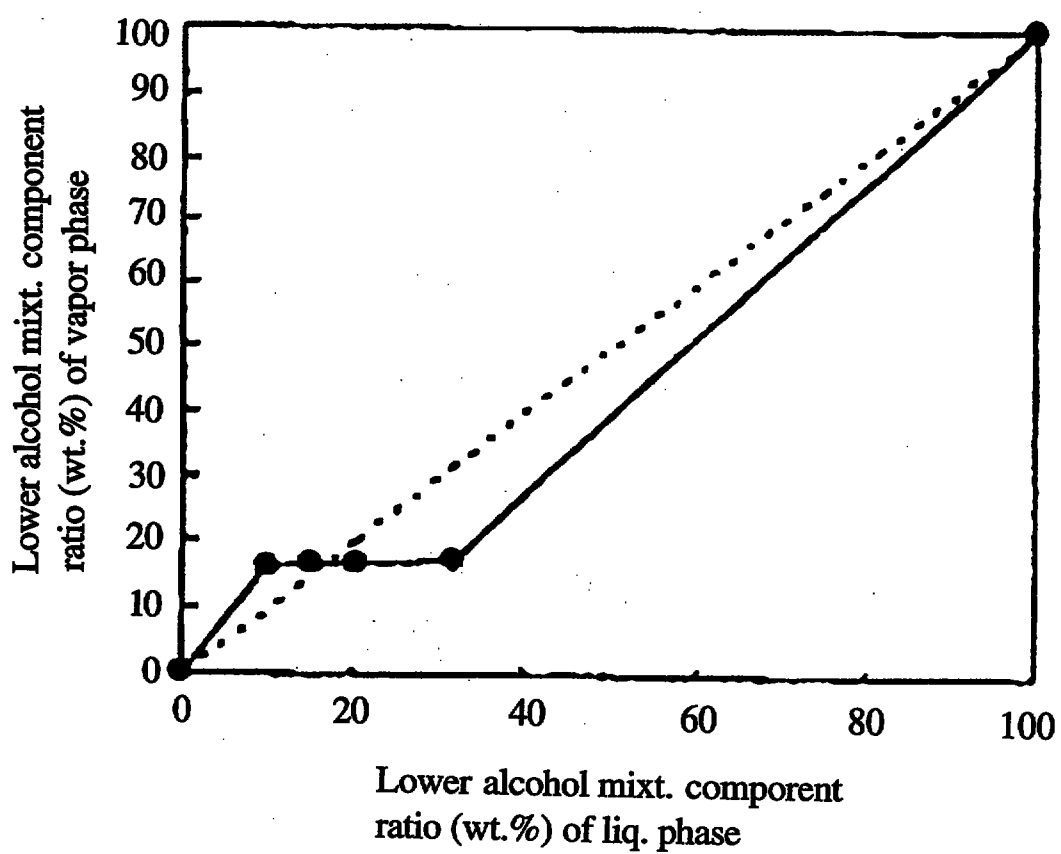
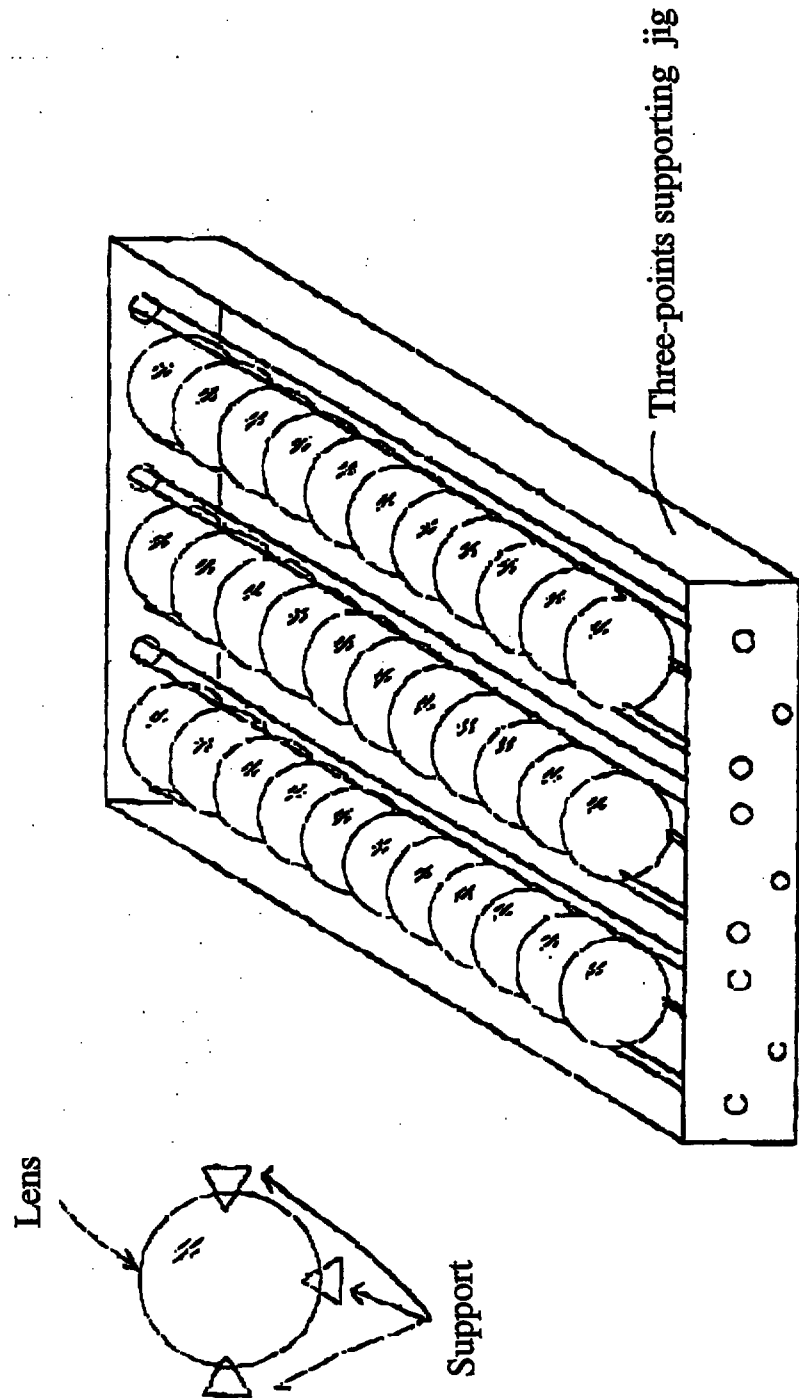


FIG. 10



zation of the composition. That is, the composition change attributed to the vaporization or evaporation during the cleaning operation is very slight.

The cleaning power will be described below. The cleaning power of the solvent-based cleaning agent composition can be expressed by the dirt dissolving capability. The solubility parameter (hereinafter referred to as "SP") is generally known as a scale for estimating the dissolving capability. The SP value is strongly influenced by the polarity of the compound. Chain compounds such as 2-methylpentane, 3-methylpentane and n-hexane as the aliphatic saturated hydrocarbon being a component of the cleaning agent composition of claim 15 have properties very similar to each other from the viewpoint of polarity because of the molecular structures. On the other hand, methanol, ethanol, isopropanol and n-propanol as the lower alcohol component have also properties very similar to each other from the viewpoint of polarity. Therefore, the cleaning power is ~~influenced~~ ^{determined} by the ratio of the component of aliphatic saturated hydrocarbon as an aggregate of 2-methylpentane, 3-methylpentane and n-hexane to the component of lower alcohol as an aggregate of methanol, ethanol, isopropanol and n-propanol.

For example, finger sebum, marking ink, waxes such

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Table 2

Highly purified satd. Satd. hydrocarbon	Running point temp. range	
	95%	99%
isooctane (C=8)	113 - 115	113 - 116
ethylcyclohexane (C=8)	129 - 133	129 - 134
isononane (C=9)	133 - 137	133 - 138
n-nonane (C=9)	150 - 151	150 - 152
n-decane (C=10)	169 - 172	169 - 173
isododecane (C=12)	189 - 194	189 - 196 169

Example 9

Fig. 2 is a sectional view of the apparatus used in this Example. Numeral 101 denotes a vapor drying tank, and a heater 102 is inserted in its bottom part. The heater 102 is supplied with heat by a steam boiler and the temperature thereof is controlled by means of a pressure regulation valve 104. A chiller coil 105 is provided at an upper part of the vapor drying tank 101, which cools and liquefies the solvent vapor. The liquefied solvent is transferred through a recovery pipe 103 and recovered in a recovery tank 106. The recovery tank 106 separates dewed and mixed water and the solvent freed of water is caused to overflow from

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Table 5

	Liq.: used in tank nos. 11-12	Distillation character- istic		Flash point (°C)
		95% running point	99% running point	
Comp. 5	1 isononane (C=9)	131 - 139	131 - 150	24
Ex. 6	2 isododecane (C=12)	189 - 196	189 - 201	64
7	3 n-tridecane (C=13)	212 - 250	212 - 260	86

Example 19

A hydrocarbon mixture consisting of 60.1% by weight of 2-methylpentane, 36.2% by weight of 3-methylpentane and 3.7% by weight of n-hexane was used as the aliphatic saturated hydrocarbon with 6 carbon atoms. A lower alcohol mixture consisting of 85.5% by weight of ethanol, 4.9% by weight of isopropanol and 9.6% by weight of n-propanol was used as the lower alcohol with 1 to 3 carbon atoms. The hydrocarbon mixture and the lower alcohol mixture were mixed together in varied proportions (lower alcohol mixture component ratio: 0, 10, 15, 20, 30 and 100% by weight in Table 7) to thereby obtain mixture compositions in an amount of 200 g each. These compositions were subjected to simple distillation at atmospheric pressure, and the boiling point of initial distillate, initial distillate composition component ratio (hereinafter referred to as "component ratio of vapor phase") and

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Table 8

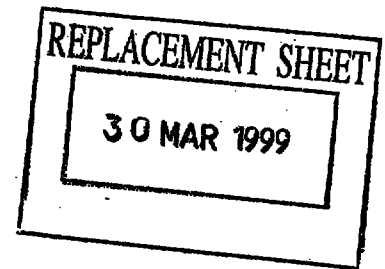
	before distilla- tion	distilla- tion 1	distilla- tion 2	distilla- tion 3	end of distilla- tion
ethanol	13.7	14.9	14.0	13.6	13.2
isopropanol	0.8	0.5	0.7	0.8	1.0
n-propanol	1.6	0.5	1.0	1.4	1.8
2-methylpentane	50.4	52.4	50.6	49.5	48.1
3-methylpentane	30.4	29.4	30.9	31.6	32.4
n-hexane	3.1	2.2	2.8	3.1	3.5
lower alcohol mixture	16.1	15.9	15.7	15.8	16.0
hydrocarbon mixture	83.9	84.1	84.3	84.2	84.0

Table 9

	before distilla- tion	liq. phase 1	liq. phase 2	liq. phase 3	end of liq. phase	distillation
ethanol	13.7	13.7	13.4	13.1	13.4	
isopropanol	0.8	0.9	1.0	1.3	1.7	
n-propanol	1.6	1.7	2.3	3.5	5.7	
2-methylpentane	50.4	49.5	48.1	45.9	42.3	
3-methylpentane	30.4	31.2	31.8	32.4	32.6	
n-hexane	3.1	3.0	3.4	3.8	4.3	
lower alcohol mixture	16.1	16.3	16.7	17.9	20.8	
hydrocarbon mixture	83.9	83.7	83.3	82.1	79.2	

Example 20

A hydrocarbon mixture consisting of 97.3% by weight of 2-methylpentane and 2.7% by weight of n-



ple 10;

Fig. 6 is a diagram showing the construction of the cleaning apparatus employed in Example 11;

Fig. 7 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 19;

Fig. 8 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 20;

Fig. 9 is a graph showing the relationship between lower alcohol mixture component ratio of liquid phase and lower alcohol mixture component ratio of vapor phase measured in Example 24; and

Fig. 10 is a perspective view of a three-points supporting jig employed in Examples 12 to 18.

Detailed Description of The Invention

According to the present invention, there is provided a precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose distillation point 95% ~~running point~~ falls within 5°C of its initial distillation point boiling point and whose 99% ~~running point~~ falls within

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10°C of its initial boiling point in distillation at 760 mmHg. Further, there is provided a precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent, replacing part of the cleaning agent adhering to the item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~running point~~ ^{distillationpoint} falls within 5°C of its ^{distillationpoint} initial boiling point and whose 99% ~~running point~~ falls within 10°C of its initial boiling point in distillation at 760 mmHg. Still further, there is provided a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics. Moreover, there is provided a precision cleaning method comprising impregnating fibrous matter with a cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6

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carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol so as to exhibit azeotropic or azeotrope-like characteristics and wiping a surface of an item to be cleaned with the impregnated fibrous matter by hand.

The saturated hydrocarbon composing the cleaning agent for use in the present invention may be one obtained by first oligomerizing gaseous propylene or butene into a mixture of hydrocarbons and then separating by distillation a fraction having 8 to 12 carbon atoms whose 95% ~~running point~~ distillation point falls within 5°C of its distillation point initial boiling point and whose 99% ~~running point~~ falls within 10°C of its initial boiling point at 760 mmHg from the mixture. The above oligomerization of gaseous propylene or butene produces a plurality of specified hydrocarbons with varied boiling points, from which the desired high-purity saturated hydrocarbon can easily be separated by subsequent distillation.

With respect to the saturated hydrocarbon for use in the present invention, the 95% ~~running point~~ distillation point falls within 5°C, preferably, within 3°C of its initial boiling point. It is still preferred that the 99.5% ~~running point~~ distillation point fall within 5°C, especially, within 3°C

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item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further treated with the cleaning agent of the present invention which consists essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~running point~~ distillation point falls within 5°C of its initial boiling point and whose 99% ~~running point~~ distillation point falls within 10°C of its initial boiling point in distillation at 760 mmHg. In this mode of the present invention, it is preferred that an isoparaffin be used as the saturated hydrocarbon. It is especially preferred that the saturated hydrocarbon be principally composed of isononane having 9 carbon atoms. With respect to the saturated hydrocarbon for use in this mode of the present invention, the 95% ~~running point~~ distillation point falls within 5°C, preferably, within 3°C of its initial boiling point. It is still preferred that the 99.5% ~~running point~~ distillation point fall within 5°C, especially, within 3°C of the initial boiling point.

It is required that the cleaning agent for removing dirt solubilize the dirt, be able to get into and out of minute hollow and do not affect the surface of the item to be cleaned. The cleaning agent of saturated hydrocarbon according to the present invention is highly miscible with dirt components such as processing

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agent cannot be uniform and the cleaning agent remains on the surface of the cleaned item in the form of spots or blocks to thereby cause the danger of stain occurrence.

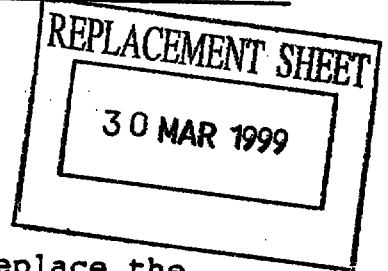
In a further specific mode of the present invention, the precision cleaning method comprises vaporizing a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~boiling point~~ ^{distillation point} falls within 5°C of its initial ^{distillation point} ~~boiling point~~ and whose 99% ~~boiling point~~ falls within 10°C of its initial boiling point in distillation at 760 mmHg and applying the vapor to an item to be cleaned so that the item to be cleaned is freed of dirt and/or dried. The vaporization of the cleaning agent is conducted by heating at boiling point or higher under atmospheric pressure or by heating while reducing the pressure. In the latter vaporization method, the above highly purified saturated hydrocarbon is introduced in a vaporization vessel having its internal pressure reduced to about 60 mmHg and heated. The internal pressure of the vaporization vessel becomes equal to the vapor pressure at heating temperature of the saturated hydrocarbon because of the vapor-liquid equilibrium. When the heating is performed at temperatures not greater than the boiling point under atmos-

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boiling point components is high in the vapor phase while the ratio of high boiling point components is high in the liquid phase. Consequently, when comparison is made between the vapor-liquid equilibrium at the initial liquid supply and that after the passage of some time, it is found that the vapor pressure is higher and the amount of the vapor is greater at the initial liquid supply. However, the heating is conducted by low-boiling-point vapor at the vapor supply, so that it may occur that the item to be cleaned is not supplied with a quantity of heat satisfactory for achieving the drying to thereby failing to dry the item. Low-boiling-point components evaporate and are lost and the amount of high-boiling-point components is increased with the passage of time, resulting in a drop of the overall vapor pressure. Therefore, with respect to the common hydrocarbon solvent, not only is control of the level of pressure reduction of the airtight treatment vessel required but also the quantity of heat must be increased to maintain the constant pressure.

The saturated hydrocarbon used in the present invention is one whose 95% ~~running point~~ ^{distillation point} falls within 5°C of its initial boiling point and whose 99% ~~running point~~ ^{distillation point} falls within 10°C of its initial boiling point in distillation at 760 mmHg. Thus, the compositions are



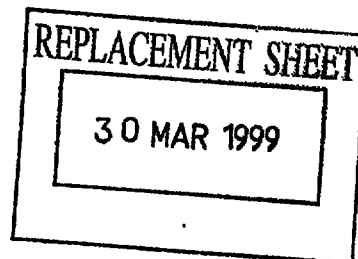
in a water insoluble solvent to thereby replace the hydrophilic solvent adhering to the optical element therewith and drying the optical element to thereby remove the water insoluble solvent from the optical element for finishing, wherein the water insoluble solvent consists essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~running point~~ ^{distillation point} falls within 5°C of its initial boiling ~~running point~~ ^{distillation point} point and whose 99% ~~running point~~ ^{distillation point} falls within 10°C of its initial boiling point in distillation at 760 mmHg. In this method, the first dipping of the optical element in the organic solvent and/or water-base cleaning agent removes most of dirt components such as pitch, wax, abrasive, finger sebum and dust therefrom. A variety of organic solvents can be used which include chlorinated solvents such as trichloroethylene and 1,1,1-trichloroethane, petroleum solvents such as alkylbenzenes and naphthenes, terpene solvents such as limonene and dipentene, glycol ether solvents such as diethylene glycol monobutyl ether and dipropylene glycol monomethyl ether and ester solvents such as ethyl lactate and dimethyl succinate. Examples of the water-base solvents include alkali cleaning agents comprising water and a small amount of additives such as a surfactant, an alkali builder and an antifoaming

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of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~boiling point~~ ^{distillation point} falls within 5°C of its initial boiling point and whose 99% ~~boiling point~~ ^{distillation point} falls within 10°C of its initial boiling point in distillation at 760 mmHg. Thus, the cleaning method not only resolves the drawbacks of the conventional hydrocarbon-based cleaning agent such as nonhazardousness to human, smell and poor finishing quality but also does not destroy the ozonosphere because of the absence of chlorine and is free from the danger of environmental pollution attributed to mixing in ground water. Further, the cleaning agent composition has the same power as that of the chlorinated cleaning agent such as freon 113, so that high-quality removal of dirt can be performed from the item.

Further, the use of the cleaning agent of saturated hydrocarbon according to the present invention enables using vapor in an amount which is stable and does not change irrespective of the passage of time, so that high-quality removal of dirt from the item to be cleaned can be performed for a prolonged period of time.

Still further, the performance of the cleaning agent composition of saturated hydrocarbon according to the present invention can be maintained for a prolonged



80°C air was blown to the item for 3 min. In the evaluation of cleaning performance after the drying step, the appearance was visually inspected to find whether or not any stain is present and to find whether or not any liquid remains on the item surface with respect to the dryability. Further, any oil remaining on the item was extracted with trichlene and the absorbance of the extract was measured. The oil removal ratio was calculated from the measurement. Evaluation results are given in Table 1. In the column "removing capability" of Table 1, the mark "o" means an oil removal ratio of over 90%, the mark "A" an oil removal ratio of 50 to 90% and the mark "x" an oil removal ratio of less than 50%. In the column "stain" of Table 1, the mark "o" means that stain was not found on the item surface and the mark "x" means that stain was found on the item surface. In Table 1, "PGM-AC" is propylene glycol monomethylacetate (b.p. 143°C) categorized as flash point classification no. 3 of dangerous commodity which was produced by Kuraray Co., Ltd., and "Daphne alpha cleaner H" is cleaning agent of isoparaffinic hydrocarbon (b.p. 210 to 263°C) categorized as flash point classification no. 3 of dangerous commodity which was produced by Idemitsu Kosan Co., Ltd. Table 2 specifies 95% ~~running point~~ distillation point and 99% ~~running point~~ distillation point

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the recovery tank 106. The overflow portion of the solvent is recycled into the vapor drying tank 101. Numeral 107 denotes a drain.

In this Example, the employed solvent was highly purified isooctane whose initial boiling point, 95% ~~running point~~ ^{distillation point} and 99% ~~running point~~ ^{distillation point} were 113°C, 115°C and 116°C, respectively, which was selected from among the saturated hydrocarbons listed in the above Table 2.

The highly purified isooctane was introduced in the vapor drying tank 101 of the above apparatus, and the boiler input steam pressure was set at 1.8 kgf/cm². The heating temperature was 117°C which was satisfactory for vaporizing the highly purified isooctane. Pressed copper parts as items to be cleaned were carried in piled form into vapor zone of the vapor drying tank 101. The vapor was applied to the surface of the pressed parts and the isooctane liquefied by the pressed parts was recovered in the vapor drying tank 101. The pressed parts were taken out 2 min later. Appearance inspection showed that there was no stain adhesion.

In this Example, the vapor drying with the highly purified isooctane enables drying contact portions of the piled parts and further enables performing the above drying by the use of the apparatus of simple

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withdrawal in vacuum. The airtight cleaning tank 201 and the vaporization tank 202 are heated by a steam boiler 215, and this heating is controlled by means of pressure control valves 216 and 217.

In this Example, the employed solvent was highly purified isononane whose initial boiling point, 95% ~~distillation point~~ ^{distillation point} and 99% ~~running point~~ ^{distillation point} were 133°C, 137°C and 138°C, respectively, which was selected from among the saturated hydrocarbons listed in the above Table 2.

The cleaning and drying process of this Example comprised carrying the item to be cleaned in the airtight cleaning tank 201, reduction of the internal pressure of the airtight cleaning tank 201, vapor introduction into the airtight cleaning tank 201, vacuum drying, leak for restoring the internal pressure of the airtight cleaning tank 201 to atmospheric pressure and withdrawal of the cleaned item.

Before starting the operation, the vaporization tank 202 was evacuated to thereby realize the vapor-liquid equilibrium of highly purified isononane. The vacuum pump 205 was operated to thereby reduce the entire internal pressure of the apparatus to 60 mmHg (-700 mmHg). Thereafter, the vapor supply valve 203 and the pressure reducing valve 204 were closed and the leak valve 218 was opened so that the internal pressure

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distillation point
~~running point~~ and 99% distillation point
~~running point~~ were 169°C, 172°C and 173°C, respectively, which was selected from among the highly purified saturated hydrocarbons listed in the above Table 2.

As a set-up for the operation of the above apparatus, the water ring pump 305 was operated to thereby reduce the entire internal pressure of the apparatus. Thereafter, the vapor supply valve 303 and the pressure reducing valve 304 were closed and the leak valve 311 was opened so that the internal pressure of the airtight cleaning tank 301 was restored to atmospheric pressure. The heater was connected to power source to thereby heat the solvent placed in the vaporization tank 302. The internal pressure of the vaporization tank 302 was so reduced that the inside of the tank was filled with the vapor in an amount corresponding to the vapor pressure at the heating temperature. The temperature of highly purified n-decane present in the vaporization tank 302 was about 160°C while the internal pressure of the vaporization tank 302 was held at 560 mmHg (-200 mmHg).

Polished metal parts having been dipped in the highly purified n-decane after dirt removal were carried in the airtight cleaning tank 301. The pressure reducing valve 304 was opened to thereby reduce the

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Tank nos. 1 and 2 were charged with organic solvent EE-4110 (cleaning agent based on terpenic hydrocarbon, produced by Olympus Optical Co., Ltd.), which was heated at 40°C and provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 3 and 4 were charged with water-base cleaning agent EE-1110 (neutral cleaning agent produced by Olympus Optical Co., Ltd.), which was heated at about 35°C and provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 5 to 7 were charged with pure water of about 1 MΩ in conductivity, which was provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec. Tank nos. 8 to 10 were charged with hydrophilic solvent IPA, which was provided with ultrasonic of 27 KHz / 600 W and oscillation of 100 mm width once/sec.

Tank no. 11 was charged with highly purified isononane having 9 carbon atoms whose ~~95% running point~~ distillation point falls at 4°C from its initial boiling point and whose ~~99% running point~~ distillation point falls at 5°C from its initial boiling point in distillation at 760 mmHg as specified in Table 2, which was provided with oscillation of 100 mm width once/sec only. Tank no. 12 was charged with the same highly purified isononane as in tank no. 11, which was not provided with ultrasonic nor oscillation. The

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Comparative Example 5

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with isononane having 9 carbon atoms whose ~~distillation point~~ distillation point 95% ~~running point~~ and 99% ~~running point~~ distillation point were 8°C and 19°C from the initial boiling point, respectively, in distillation as indicated in Table 5. This isononane had large distillation temperature range and thus its purity was low. Evaluation results are given in Table 4. The defect ratio was as high as 13/100 with respect to the post-cleaning evaluation and as high as 25/100 with respect to the post-coating evaluation. Although the drying velocity was high without any disadvantage, the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.

Comparative Example 6

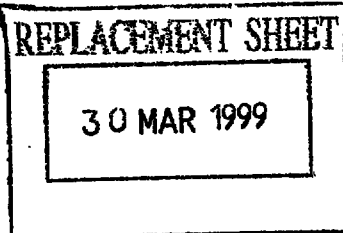
The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with isododecane having 12 carbon atoms whose ~~distillation point~~ distillation point 95% ~~running point~~ and 99% ~~running point~~ distillation point were 7°C and 12°C from the initial boiling point, respectively, in distillation as indicated in Table 5. Evaluation results are given in Table 4. The defect ratio was as

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high as 42/100 with respect to the post-cleaning evaluation and as high as 56/100 with respect to the post-coating evaluation. Although the drying velocity was high without any disadvantage, the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.

Comparative Example 7

The same procedure as in Example 12 was repeated except that tank nos. 11 and 12 of the cleaning line were charged with n-tridecane having 13 carbon atoms whose 95% ~~running point~~ ^{distillation point} and 99% ~~running point~~ ^{distillation point} were 38°C and 48°C from the initial boiling point, respectively, in distillation as indicated in Table 5. Evaluation results are given in Table 4. The defect ratio was as high as 65/100 with respect to the post-cleaning evaluation and as high as 82/100 with respect to the post-coating evaluation. The drying velocity was relatively low, and the distillation temperature range from the initial boiling point was large to show a large content of high-boiling-point components. Thus, a multiplicity of lenses suffered from stain.



What is claimed is:

1. A precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent consisting essentially of at least one saturated hydrocarbon having 8 to 12 carbon atoms whose ~~95% running point~~ ^{distillation point} falls within 5°C of its initial ~~boiling point~~ ^{distillation point} and whose 99% ~~running point~~ ^{distillation point} falls within 10°C of its initial boiling point in distillation at 760 mmHg._____
2. The precision cleaning method according to claim 1, which further comprises treating the cleaning agent used in dirt removal with water so that impurities mixed into the cleaning agent are separated off.
3. The precision cleaning method according to claim 1, wherein the saturated hydrocarbon is an iso-paraffin.
4. The precision cleaning method according to claim 1, wherein the saturated hydrocarbon is principally composed of isononane having 9 carbon atoms.
5. A precision cleaning method comprising vaporizing a cleaning agent consisting essentially of at



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least one saturated hydrocarbon having 8 to 12 carbon atoms whose 95% ~~running point~~ ^{distillation point} falls within 5°C of its ^{distillation point} initial boiling point and whose 99% ~~running point~~ falls within 10°C of its initial boiling point in distillation at 760 mmHg and applying the vapor to an item to be cleaned so that the item to be cleaned is freed of dirt and/or dried.

6. The precision cleaning method according to claim 5, wherein the item to be cleaned is carried in a cleaning treatment chamber, the cleaning treatment chamber has its internal pressure reduced to thereby introduce therein the vapor of the cleaning agent so that the item to be cleaned is freed of dirt and/or dried and the pressure of the cleaning treatment chamber is restored to atmospheric pressure.

7. A precision cleaning method comprising removing dirt from an item to be cleaned with the use of a cleaning agent, replacing part of the cleaning agent adhering to the item with a hydrophilic solvent or a water insoluble solvent and drying the item, wherein, after the replacement and before the drying, the item is further treated with a cleaning agent consisting essentially of at least one saturated hydrocarbon



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having 8 to 12 carbon atoms whose 95% ~~running point~~ ^{distillation point} falls within 5°C of its initial boiling point and whose 99% ~~running point~~ ^{distillation point} falls within 10°C of its initial boiling point in distillation at 760 mmHg.

8. The precision cleaning method according to claim 7, wherein the saturated hydrocarbon is an iso-paraffin.

9. The precision cleaning method according to claim 7, wherein the saturated hydrocarbon is principally composed of isononane having 9 carbon atoms.

10. The precision cleaning method according to claim 7, wherein, after the replacement and before the drying, the item is dipped in said cleaning agent consisting essentially of at least one saturated hydrocarbon and lifted at a rate of not greater than 70 mm/s from the cleaning agent to thereby depart from its liquid level.

11. A precision cleaning method comprising the steps of ^{removing dirt from} ~~dipping an optical element~~ ^{with the use of} ~~to be cleaned in an~~ organic solvent and/or a water-base cleaning agent, ~~to thereby remove dirt, dipping the optical element in~~



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~~water to thereby~~ ^{rinsing} ~~rinse off~~ the organic solvent and/or
water-base cleaning agent adhering to the optical
element, ^{with the use of water, replacing} ~~dipping the optical element in a hydrophilic~~
~~solvent to thereby replace the water adhering to the~~
optical element ^{with a hydrophilic solvent, replacing} ~~therewith, dipping the optical element~~
~~in a water insoluble solvent to thereby replace the~~
hydrophilic solvent adhering to the optical element
^{with a water insoluble cleaning agent} ~~therewith~~ and drying the optical element to thereby
remove the water insoluble ^{cleaning agent} ~~solvent~~ from the optical
element for finishing, wherein the water insoluble
^{cleaning agent} ~~solvent~~ consists essentially of at least one saturated
hydrocarbon having 8 to 12 carbon atoms whose 95%
^{distillation point} ~~running point~~ falls within 5°C of its initial boiling
point and whose 99% ^{distillation point} ~~running point~~ falls within 10°C of
its initial boiling point in distillation at 760 mmHg.

12. The precision cleaning method according to
claim 11, wherein the saturated hydrocarbon is an
isoparaffin.

13. The precision cleaning method according to
claim 11, wherein the saturated hydrocarbon is composed
of isononane having 9 carbon atoms.

14. The precision cleaning method according to



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claim 11, wherein the water insoluble solvent is treated with water after use in the hydrophilic solvent replacement so that the hydrophilic solvent is separated off from the water insoluble solvent to thereby regenerate the water insoluble solvent.

~~15. A cleaning agent composition for hand wiping comprising 66 to 90% by weight of at least one aliphatic hydrocarbon with 6 carbon atoms containing at least 44% by weight of 2-methylpentane and 10 to 34% by weight of at least one lower alcohol with 1 to 3 carbon atoms containing at least 85% by weight of ethyl alcohol to thereby exhibit azeotropic or azeotrope-like characteristics.~~

16. The cleaning agent composition for hand wiping according to claim 15, whose total content of n-hexane, methanol, isopropanol and n-propanol is less than 10% by weight based on all of the composition.

17. The cleaning agent composition for hand wiping according to claim 15 or 16, whose water content is less than 2000 ppm by weight.

~~18. The cleaning agent composition for hand~~



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~~wiping according to any of claims 15 to 17, wherein the~~
total amount of components having a boiling point of
120°C or higher at 760 mmHg is less than 1% by weight
and the total amount of components having a boiling
point of 170°C or higher at 760 mmHg is less than 1000
ppm by weight.

19. A precision cleaning method comprising im-
pregnating fibrous matter with a cleaning agent compo-
sition for hand wiping comprising 66 to 90% by weight
of at least one aliphatic hydrocarbon with 6 carbon
atoms containing at least 44% by weight of 2-methylpen-
tane and 10 to 34% by weight of at least one lower
alcohol with 1 to 3 carbon atoms containing at least
85% by weight of ethyl alcohol so as to exhibit azeo-
tropic or azeotrope-like characteristics and wiping a
surface of an item to be cleaned with the impregnated
~~fibrous matter by hand.~~

