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CLEANING OR TREATING PROCESS

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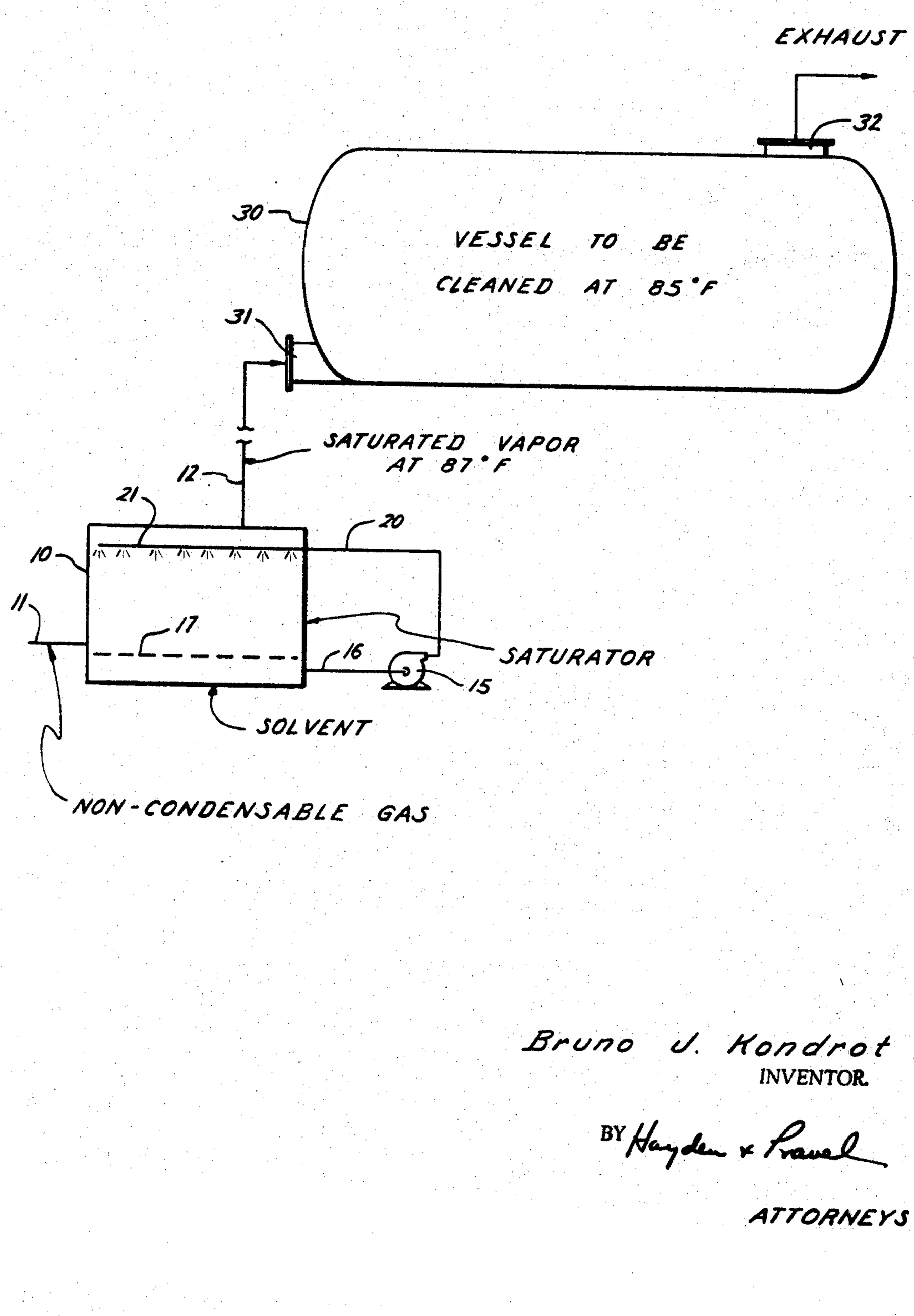

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CLEANING OR TREATING PROCESS

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ABSTRACT OF THE DISCLOSURE

A cleaning process wherein a cleaning solvent in vapor form is mixed with a non-condensable gas and wherein the dew point of the solvent is at or within a few degrees above the temperature of the article being treated, whereby the solvent may be condensed in a thin film on an article to be cleaned.

This invention relates to new and useful improvements in cleaning or treating processes.

In the cleaning of articles, particularly metal articles such as vessels or pipes, it has generally been the practice to use a liquid cleaning agent such as an acid, or in some instances steam. When using the liquid, there have been several serious problems, especially with large volume vessels or pipes. For example, if it was necessary to clean the interior walls of a large vessel, the vessel would have to be filled with a large volume of liquid or tremendous volumes of liquid would have to be circulated through the vessel. With such large volumes of liquid, it has been virtually impossible to get an adequate velocity of flow for effective rapid cleaning. Furthermore, after the vessel has been cleaned, the large volume of liquid acid or other cleaning agent must be disposed of, which is often a difficult and expensive procedure.

When steam has been used in the past for cleaning articles at ambient temperatures, it has been found that a large amount of steam is wasted as it condenses on successive portions of the vessel, pipe, or other article to gradually heat same to the steam temperature. An undesirable delay in the effective action of the steam plus the necessity for the removal of large quantities of condensed water have thus resulted in the prior practice with steam.

It is an object of the present invention to overcome the problems and disadvantages of the prior cleaning method by providing a new and improved process wherein articles may be cleaned rapidly, efficiently and with a minimum of liquid cleaning agent.

An important object of this invention is to provide a new and improved process for treating an article or articles for cleaning purposes or otherwise, wherein a vapor having a cleaning or treating liquid therewith is contacted with the surface to be treated so as to condense a relatively thin film of the liquid on such surface for cleaning or other treatment.

Another object of this invention is to provide a new and improved process wherein a vapor mixture of a non-condensable gas and a condensable treating liquid in a vapor state are provided at a selected temperature, pressure and composition, for use in cleaning or other treatment of an article or articles by moving such vapor at high velocity across the surface of such object or objects.

A further object of this invention is to provide a new and improved process for condensing a thin film of liquid onto a surface from a vapor by adjusting the condensation temperature of the vapor so that it is equal to or slightly higher than the temperature of the surface on which the liquid is to be condensed whereby the amount of the condensed liquid is at a minimum while obtaining an effective washing action therewith.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

The figure of the drawings is a schematic illustration of the preferred method of this invention.

In the dawings, a schematic illustration of the process of this invention is shown. Briefly, the process or method of this invention involves the use of a mixture of a non-condensable gas with a condensable reactive treating liquid in a vapor state wherein the quantities of the non-condensable gas and the liquid, the temperatures and the pressures are controlled so that such mixture may be circulated into contact with an object to be cleaned or otherwise treated with the dew point of the reactive liquid at approximately the temperature of the article to be cleaned or otherwise treated. With the process of this invention, the necessity for circulating large volumes of liquid in a vessel, pipeline, or similar article to be cleaned or treated is eliminated. Additionally, the process provides for the deposit of a relatively thin film of the reactive treating liquid on the surface of the article to be cleaned or otherwise treated while moving the vapor mixture across such surface at a relatively rapid flow rate. By providing the vapor mixture so that it has a condensing temperature for the treating liquid at or slightly above the temperature of the article to be treated, there is substantially no loss of the heat in heating the article and therefore only the necessary amount of liquid is condensed for the cleaning or other treatment.

In carrying out the method of this invention, a gas which is non-condensable at the temperatures and pressures employed in the process is first mixed with the treating liquid vapor so as to provide the saturated vapor. As shown in the drawings, such vapor mixture may be provided with any suitable equipment such as a tank or chamber **10** which has an inlet line **11** for the non-condensable gas and an outlet line **12** for the saturated vapor.

The chamber **10** also has a provision for circulating and spraying the treating liquid so as to intimately mix the non-condensable gas with the treating liquid for vaporizing same to create the saturated vapor. Thus, a pump **15** is preferably employed for such circulation by withdrawing the reactant liquid through an outlet line **16** from the tank or chamber **10** at a level below the upper level **17** of the solvent or other liquid. The pump **15** then discharges the liquid through line **20** back into the upper portion of the chamber or tank **10** through suitable sprays **21** so as to create a mist of the liquid within the chamber **10** while the non-condensable gas is flowing therethrough for discharge at the line **12**.

The non-condensable gas preferably provides the necessary heat for the latent heat of evaporation which takes place when the liquid in the mist form evaporates within the tank or chamber **10** and is thus combined with the non-condensable gas to form the saturated vapor discharged through the line **12**. Also, the non-condensable gas should be at such an entering temperature when it enters through line **11** into the tank or chamber **10** to provide the saturated vapor at the ultimate temperature desired for the treatment of the work or article, as will be more evident hereinafter. Thus, the non-condensable gas should provide both the latent heat of vaporization for vaporizing the liquid within the chamber **10** to create the saturated vapor and it should also provide sufficient heat to have a temperature of the saturated vapor at or slightly above the temperature of the vessel, pipeline or other article to be cleaned or otherwise treated.

Instead of providing the heat through the non-condensable gas, heat may be provided by any other means such as by heating the chamber **10** to cause an evaporation of the solvent or other liquid within the chamber or tank **10**. The amount of heat which is required may be readily calculated by those skilled in the art in advance of the process, depending upon the particular materials employed, and the temperatures and pressures of the operation. If the pressure remains constant, which is the usual case, the temperatures will be the controlling factor for regulating the composition of the vapor mixture. However, in some instances, it is desirable to increase the pressure of the vapor mixture in the vicinity of the area of the object to be cleaned so as to cause a condensation of the treating liquid by change in pressure rather than by the change in temperature.

As a general proposition, where the pressure remains constant throughout the process, the composition of the saturated vapor should have such a mol fraction of the condensable treating liquid with respect to the non-condensable gas that the mol fraction multiplied by the total pressure in the system equals the vapor pressure of the undiluted condensable treating liquid. For example, if the treating liquid is water and the non-condensable gas is air, the total pressure in the system is assumed to be 760 mm. Hg. If the saturated vapor is desired at about 76° F. to place such condensation temperature slightly above the vessel or other article which is assumed to be at about 75° F., then the vapor pressure of water at 76° F. equals 26 mm. Hg. 100 mols of the saturated vapor would therefore contain $100 \times 26/760$, or 3.43 mols of water and 96.57 mols of air. With the quantities of water and air thus in proportion and at 76° F., condensation of the water will occur on the vessel or other article when the temperature is at 75° F. or below.

The temperature of the work is the controlling factor in the process of this invention, so that the saturated vapor is adjusted so that it is provided with a condensation or dew point slightly above the temperature of the vessel or other article to be cleaned or treated. By the foregoing calculations, which themselves are known in the art, the saturated vapor may thus be provided at the condition desired for the particular temperatures and pressures being used.

It will be understood that the term "non-condensable gas" as used herein and in the claims refers to a gas which is normally not condensable at the temperatures and pressures employed. For example, the non-condensable gas may be air, nitrogen, the exhaust gas from an internal combustion engine, nitrogen oxide or dioxide, carbon monoxide or carbon dioxide, methane and even oxygen if an inhibitor is provided to prevent explosion. The treating liquid is one that reacts chemically with the material to be removed and it will vary depending upon the particular material to be removed. For cleaning purposes, acids such as hydrochloric acid, sulphur dioxide, sulphur trioxide and nitric acid may be used. Also, ammonia (NH_3), various amines and chlorinated organic compounds may be employed for cleaning and similar operations.

In carrying out the process of this invention, the saturated vapor is passed from line **12** to the article to be cleaned. As illustrated in the drawings, when a vessel **30** is to be cleaned, the saturated vapor is fed from line **12** into the interior of the vessel and then is exhausted through a suitable opening at the other end of the vessel from the end where the vapor enters. Thus, as illustrated in the drawings, the vapor enters at the inlet **31** of the vessel **30** and is exhausted at the outlet **32**. In the example shown in the drawings, the vessel is assumed to be at 85° F. so that the saturated vapor is provided at 87° F. or within a few degrees above the temperature of the vessel **30**. The practical limits of control will dictate how close the dew point of the saturated vapor is with respect to the vessel to be cleaned, since theoretically the saturated vapor could be at the same temperature as the vessel to be cleaned. However, due to practical limitations, it is ordinarily desirable to have the saturated vapor several degrees higher in temperature than the vessel to be cleaned or otherwise treated. For that reason, the drawings indicate saturated vapor at 87° F. The vapor may be moved very rapidly through the interior of the vessel **30** by any suitable blowing equipment such as fans or pumps (not shown) so that a rapid contact of the interior surface of the vessel with the vapor is provided. As the vapor flows through the interior of the vessel **30**, a thin film of the reactant liquid in the vapor is condensed on the interior surface of the vessel **30** for cleaning action or other purpose. A washing action is thus obtained with a very small amount of actual liquid in the vessel. This is particularly advantageous in large vessels which would require many gallons of liquid if a surface material were to be removed with a liquid circulated within the vessel. Also, as previously pointed out, the present invention provides for the movement or flow of the vapor through the vessel at a fairly rapid rate as compared to the flow of any liquid which might be attempted to be moved through a vessel when full of such liquid.

In the event the vessel or other article is not isothermal throughout the area to be contacted by the vapor, the saturated vapor may be adjusted for several of the parts at the different temperatures. Thus, if a large vessel is exposed to the sun on one side and therefore is at a higher temperature than on the cooler shady side, the vapor may initially be at a temperature for condensing on the cooler portions of the vessel or article and then the vapor may be adjusted for condensing on the warmer portions of the vessel or article.

The process of this invention has been illustrated with a vessel **30** such as a tank because the process is especially suitable for the cleaning of the interior of such a vessel as compared to prior art methods. However, it will be understood that the method of this invention may be useful in treating other types of articles such as pipes or pipelines or other sources.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A process for cleaning the interior portions of a hollow vessel comprising the steps of:

(a) mixing outside of said vessel, at or within a few degrees above the temperature of said vessel, a non-condensable gas with a vaporized condensable reactive cleaning agent so as to saturate said gas with said agent at said temperature,

(b) feeding said saturated gas to said vessel, and

(c) thereafter flowing the saturated gas at a high velocity through the vessel to rapidly contact said saturated gas with the interior portions of the vessel to

condense the reactive cleaning agent in a thin film on said portions for reactive cleaning action.

2. The process of claim **1**, wherein the pressure of the gaseous mixture is increased in the vicinity of the interior portions of said vessel to cause the condensation of the reactive cleaning agent on said portions.

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