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PROCESS OF CLEANING

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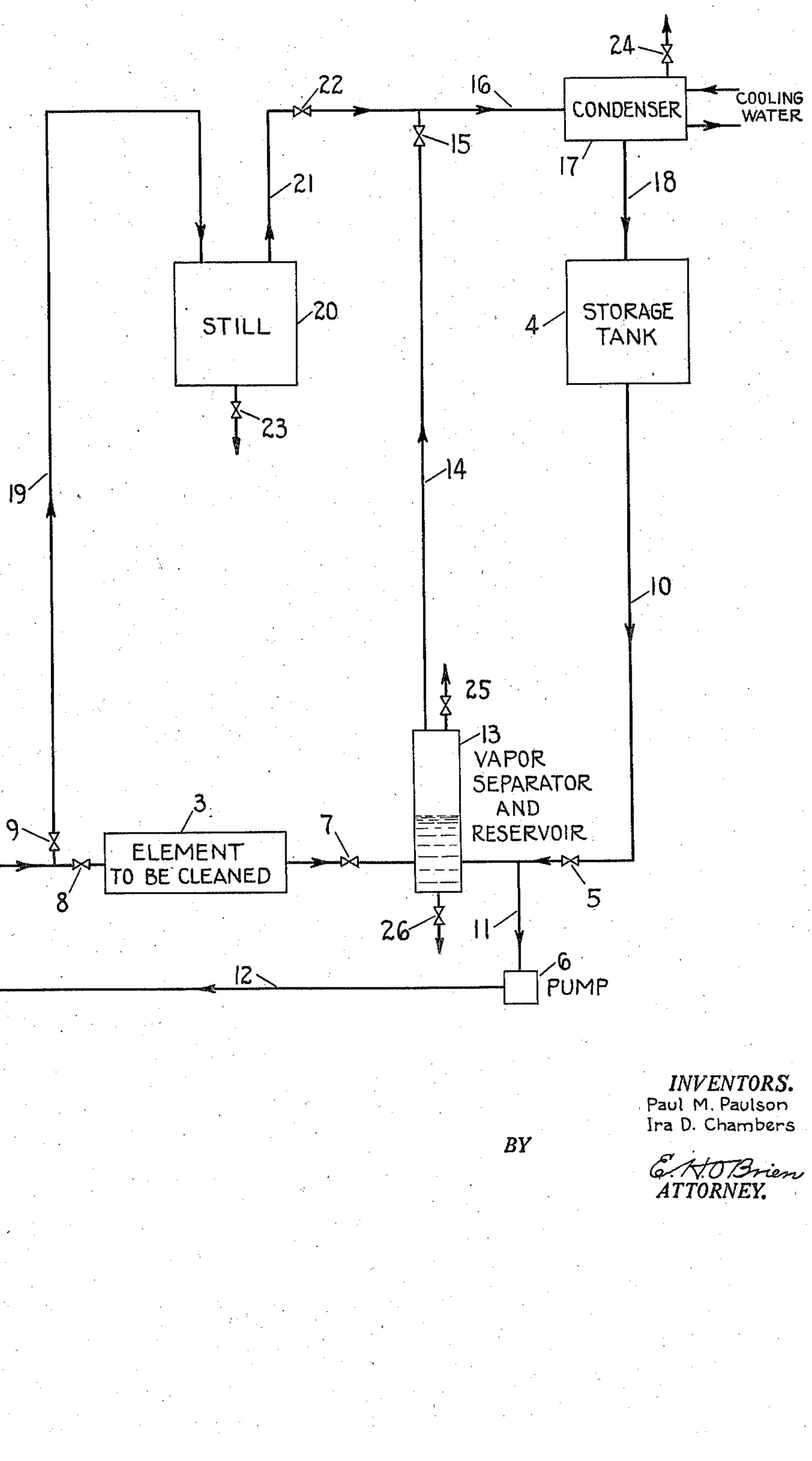



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## PROCESS OF CLEANING

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This application relates to an improved method and apparatus for removing oil, grease and other foreign matter from interior surfaces which are difficult of accessibility. More particularly it relates to a process of cleaning and a system for carrying said cleaning process into effect for use in cleaning the interior surfaces of heat exchangers generally such as condensers, preheater coils, superheater elements, and other pieces of apparatus which are not readily cleaned by other methods.

It is well known that heat transmitting surfaces such as the interior surfaces of condensers in contact with which steam is condensed become coated with oil or grease after certain periods of use. The deposition of grease, oil and/or carbon from any hydrocarbon material passed through preheater coils, superheater elements etc. materially reduces the efficiency of the heat transmitting surfaces and must be removed therefrom in order that satisfactory operation may be continued. Similarly in installations in which a fuel oil is preheated prior to its introduction into a furnace, cracking still or treatment apparatus, it is usual for carbon to deposit on the interior surfaces of the preheater pipes or coils. The carbon is usually securely held in a layer of bituminous oily or asphaltic material and is exceptionally difficult to remove by ordinary cleaning processes.

It is one of the objects of our invention to develop a cleaning process which is suitable for cleaning these interior surfaces which are normally difficult of access and which usually become coated during periods of use with oil, bituminous or asphaltic deposits, carbon, etc. Moreover it is one of the objects of our invention to employ for the cleaning of these surfaces and removal of the foreign materials adhering thereto, a solvent for hydrocarbon substances and more particularly a volatile solvent such as a chlorinated hydrocarbon. Among the chlorinated hydrocarbons which are suitable for use in cleaning we may specify trichlorethylene having a boiling point of 87° C. as our preferred solvent, although perchlorethylene, ethylene dichloride, beta-trichlorethane, carbon tetrachloride, and other chlorinated hydrocarbons of this general group will be found suitable. Trichlorethylene is preferred because of its superior solvent action and enhanced stability at elevated temperatures and in contact with water.

The use of a volatile solvent in vapor form for the cleaning of heat exchange apparatus has been previously proposed but in practice such a method is not satisfactory. We have found that in practice condensation of a vapor on the interior surfaces to be cleaned is not necessary for thorough removal of the adhering grease and/or solid materials but mere circulation of the liquid solvent, preferably hot, through the apparatus will normally result in a more satisfactory cleaning.

It is another of the objects of our invention to provide a system in which the liquid solvent, generally a chlorinated hydrocarbon, is circulated by forced circulation through the conduits of the superheater, heat exchanger, condenser, or other element which is to be cleaned. Moreover it is still another of the objects of our invention to provide means for distilling and reclaiming the said solvent at the conclusion of the cleaning operation in order that it may be purified from its dissolved solids and returned in a substantially pure state to a storage tank where it may be subsequently used in another cleaning operation. A further object of our invention is to provide a vapor separator in conjunction with the liquid treating apparatus and means for condensing any vapor which may be separated in the vapor separator, thereby returning it to the cleaning process as liquid and preventing its loss by escape to the atmosphere. Another object of our invention is to provide means by which the volume of liquid which is present within the element being cleaned at the conclusion of the liquid cleaning process may be vaporized therein, the vapor then suddenly released and allowed to flow out through a condenser where it is condensed and returned to the storage tank. In this way the tortuous elements which frequently form the interior passages of heat exchange apparatus may be blown out by pressure developed by the vaporized solvent itself, thereby completing the removal of whatever solids may still be adhering to the surfaces at the conclusion of the liquid cleaning phase of our process. The erosive action of the solvent in the form of vapor moving at fairly high velocity is added to the solvent action of the liquid used for the cleaning. Of course all the solvent remaining in the apparatus is removed by this step.

These and further objects of the invention will be apparent from the description which follows which is the best method known to us of carrying out our novel process of cleaning and degreasing the interior surfaces of heat exchange apparatus and similar equipment. The process is described in connection with the appended schematic drawing which illustrates one arrange-

ment of an apparatus especially suitable for carrying out the cleaning process.

The element to be cleaned, which may be a heat exchange apparatus, such as a condenser, preheater, etc. is indicated by the numeral 3. This piece of equipment frequently contains a number of pipes, or coils, surrounded by a jacket through which cooling water or a heat supplying medium such as steam may be circulated. Of course it sometimes happens that the passages to be cleaned surround the pipes or coils through which the cooling liquid or steam circulates when the heat exchanger is in use. The passages to be cleaned are frequently helical or spiral in form and obviously the walls of these channels are difficult of access for ordinary cleaning methods. If the element 3 does not include means by which heat may be applied thereto, the system should also include some means such as a steam jacket, steam jet, or even an open flame by which the conduits to be cleaned may be heated. This is necessary only where the device being cleaned has no elements for the passage of fluid other than those which are fouled with the foreign material to be removed. If the element is a condenser, it is desirable that the usual water passages which normally provide for passage of the cooling liquid may be utilized for the transfer of steam so that the device may function as a heater during that portion of our process wherein a liquid solvent present within the conduits of the element which is being cleaned is vaporized.

The element numbered 4 represents a storage tank in which a certain quantity of clean solvent is contained at the start of the cleaning operation. The quantity of solvent necessary when a liquid chlorinated hydrocarbon such as trichlorethylene is used varies normally in volume from four to ten times the volume of the conduits in the heat exchange apparatus which are to be cleaned. A large volume of liquid is desirable since the greater the amount of liquid the larger is the dilution of the solvents that may be dissolved therein at the conclusion of the cleaning process. Obviously also a large amount of liquid is more effective in removing the grease and solid deposits than a smaller quantity. Frequently in practice it becomes desirable to subject the piece of equipment being cleaned to two or more successive charges of fresh liquid in order that the surface may not be fouled by deposits left therein by the highly polluted liquid used for cleaning, during the subsequent blowing out phase of our process.

At the commencement of operations, valves 5, 7 and 8 are opened and valve 9 is closed. The pump 6 is started and the solvent is pumped from tank 4 through pipe lines 10, 11 and 12 and through valves 5 and 8 to the apparatus being cleaned 3. Here the liquid solvent travels through the passages to be cleaned which may be somewhat tortuous and are always rather narrow and constricted, and emerging, flows through valve 7 into the vapor separator and storage reservoir 13. Here any vapor evolved during the operation is separated from the liquid and the liquid is again forced through pipe line 11 on the suction side of pump 6 and through pipe line 12 into the same circuit during which additional cleaning takes place. In practice, of course, the circuit comprising pipe lines 11 and 12, valves 7 and 8, pump 6 and the liquid separator and reservoir 13 is filled with liquid. At the commencement of operations the vapor separator and reservoir 13 become filled with a certain amount of liquid, represented by the line indicating its level on the drawing, and this volume remains substantially unchanged during the liquid circulation process.

As previously indicated, any vapor separated at the separator 13 is allowed to flow out from the apparatus. The vapor outflows through pipe line 14, valve 15, which is open, and pipe line 16 to the condenser 17. Here the vapor is condensed and returned through pipe line 18 to the storage tank 4. Condenser 17 may be water cooled as shown. Valve 22 in pipe line 21 is closed during this portion of the cleaning process.

During the liquid treatment process, as an alternative procedure we may supply heat to the coils of the heat exchange apparatus being cleaned, by the application of heat directly to this apparatus. Part or all of the liquid within the coils or interior surfaces may be vaporized thereby. When the solvent is vaporized the volatilization dislodges to a substantial extent the solid particles attached to the surfaces and carries them out of the heat exchanger.

As another procedure, the liquid solvent may be forced in under pressure and vaporized, either in part or completely, within the element being cleaned. Sudden release of the pressure causes rapid expansion of the vapors which will serve to dislodge the solid particles which adhere to the surfaces being cleaned. Thus it is possible to dislodge the solid particles by the sudden volatilization of the liquid solvent alone, or the particles may also be dislodged by the rapid expansion of the vapor due to sudden release in pressure.

In any event the vapor separator 13 serves to separate the vapors from the liquid after the solvent leaves the heat exchanger being cleaned, 3. The liquid is returned to the cleaning process directly while the vapor is condensed in condenser 17 and returned in tank 4.

If desired, heat may be applied to the element being cleaned merely for the purpose of heating the liquid solvent with which the surfaces are being cleaned. But, as desired, either part or all of the solvent may be vaporized within the element being cleaned as previously explained. Our invention contemplates supplying liquid to the heat exchanger to be cleaned and removing therefrom either liquid and vapor, or vapor alone, thus dislodging solid particles held therein by the explosive action of the liquid when it is suddenly vaporized within the superheater. It also contemplates forcing the liquid solvent into the element to be cleaned under pressure, its outflow being prevented by closing valve 7, and vaporizing the solvent, either partially or completely, while it is held within the element. Then sudden release of pressure allows sudden expansion of the vapors thereby dislodging solid particles and forcing them and any liquid that remains from the element. This takes advantage of the force exerted by sudden expansion in order to assist the cleaning operation by forcibly stripping solid particles from the surfaces being cleaned and carrying them from the element.

After the liquid solvent is circulated for a period of time sufficient to accomplish the desired cleaning which period may vary from ten minutes to two hours, valves 7 and 8 are closed and the circulation of liquid through the element being cleaned, 3, is stopped. The liquid in the system comprising storage tank 4, pipe lines 10 and 11,

pump 6, and vapor separator and storage reservoir 13, is then pumped through the pipe line 12, valve 9, which is now opened, and pipe line 19 to the still 20. Here it is distilled, valve 22 being now opened. Valve 15 is closed. The vapors of the solvent on emerging from the condenser 20 flow through the pipe lines 21 and 16 to the condenser 17 where they are condensed and returned through pipe line 18 to the storage tank 4. During the process of distillation and after all the liquid is pumped into the still 20, the valve 5 is closed so that the condensed liquid remains within the storage tank 4 and pipe line 10. In this way the liquid is purified of the dissolved solids, these impurities being left behind in the still. A clean-out valve, 23, is provided for removing these impurities from the still when their removal is desired.

At the conclusion of the distillation and condensation operation, heat is applied to the element being cleaned, 3, either by means of the steam jacket or otherwise, utilizing if possible the normal conduits in the apparatus if these are available or an external source of heat such as a steam jet if not available. The liquid remaining within the conduits of the element 3 is thus vaporized and perhaps heated to a temperature higher than its boiling point. After complete vaporization is attained, valve 7 may be opened and the vapors which have been heated to a relatively high temperature escape through valve 7, through vapor separator and reservoir 13, pipe line 14, valve 15 and pipe line 16 to the condenser 17. Valve 22 is closed during this portion of the process. The vapors emerge from the heat exchange apparatus being cleaned at relatively high speed and thus carry out with them any remaining solid particles which may still adhere to the interior surfaces being cleaned. In passing through vapor separator and reservoir 13, the vapor velocity is lowered and thus the solid particles which are entrained in the vapor are left behind. Substantially pure vapor is therefore conveyed on to the condenser 17. Here the vapor is condensed, and the substantially pure condensate is returned through pipe line 18 to storage tank 4. Advantage is taken of the velocity of vapors of the volatile solvent itself for blowing out the heat exchange apparatus at the conclusion of the cleaning process to insure thorough removal of any solid materials which may still be adhering to the interior surfaces thereof. These solid materials collect in element 13 and may be dissolved during the process of cleaning the next superheater by the solvent action of the liquid. They may also be removed through clean-out opening 26. Only substantially pure solvent collects in the storage tank 4 and the system or apparatus is therefore available for immediate use in another cleaning operation.

Subsequently the system is vented to the atmosphere by opening the valve 24 on the condenser 17. Any vapors remaining in the system are thus permitted to escape to the outer atmosphere. At this time it may be noted that the valve 25 is provided on the vapor separator and reservoir 13 so that this element may be filled with liquid to any desired level before commencing the cleaning of another heat exchanger.

Our invention may be applied to cleaning all devices wherein the interior surfaces are difficult of access. In such circumstances manual cleaning or any cleaning method in which an operator must remove the adhering deposit mechanically and carry it away are of course impossible. As such devices we have in mind heat exchange apparatus generally, such as evaporators, heaters, coolers, condensers, preheaters, the interior surfaces of transformers, or electrical apparatus in which a liquid insulating material is employed. Wherever in the appended claims we refer to "heat exchange apparatus" we mean to include within the scope of this term all structures having conduits which are more or less difficult of access and which must be cleaned in order that the piece of equipment may remain in efficient operation.

Having thus described our invention, what we desire to secure by Letters Patent is:

1. A process for cleaning the interior surfaces of heat exchangers which comprises subjecting said surfaces to the action of a volatile chlorhydrocarbon solvent in liquid form, vaporizing said solvent by the application of heat while it is retained within the heat exchanger, and then releasing said solvent vapors from said heat exchanger, the vapors being thereby permitted to emerge from the heat exchanger at a velocity sufficient to carry out the solvent and solid particles which may be present within the heat exchanger.

2. A process for cleaning the interior surfaces of heat exchangers which comprises subjecting said surfaces to the solvent action of trichlorethylene in liquid form, vaporizing said trichlorethylene by the application of heat while it is retained within said heat exchanger, and then releasing said trichlorethylene vapors from said heat exchanger, the vapors being thereby permitted to emerge from the heat exchanger at a velocity sufficient to carry out the trichlorethylene solvent and solid particles which may be present within the heat exchanger.

3. A process for cleaning the interior surfaces of heat exchangers which comprises subjecting said surfaces to the action of a volatile chlorhydrocarbon solvent under pressure, applying heat to the heat exchanger to volatilize said solvent, and then suddenly releasing said pressure to remove from said superheater solid particles previously dislodged from said interior surfaces, and to dislodge additional solid particles by the sudden expansion of the vapors of said volatile solvent.

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