

[54] AIR SCRUBBER

[76] Inventor: Charles D. McNeely, 3060 Killian Rd., Uniontown, Ohio 44685

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[58] Field of Search 55/228, 96, 242, 55/267, 268, 269, DIG. 36, 418, 272, 286, 301, 350; 134/10, 11, 40, 31, 12; 126/299; 98/115 K; 110/8 R, 8 A

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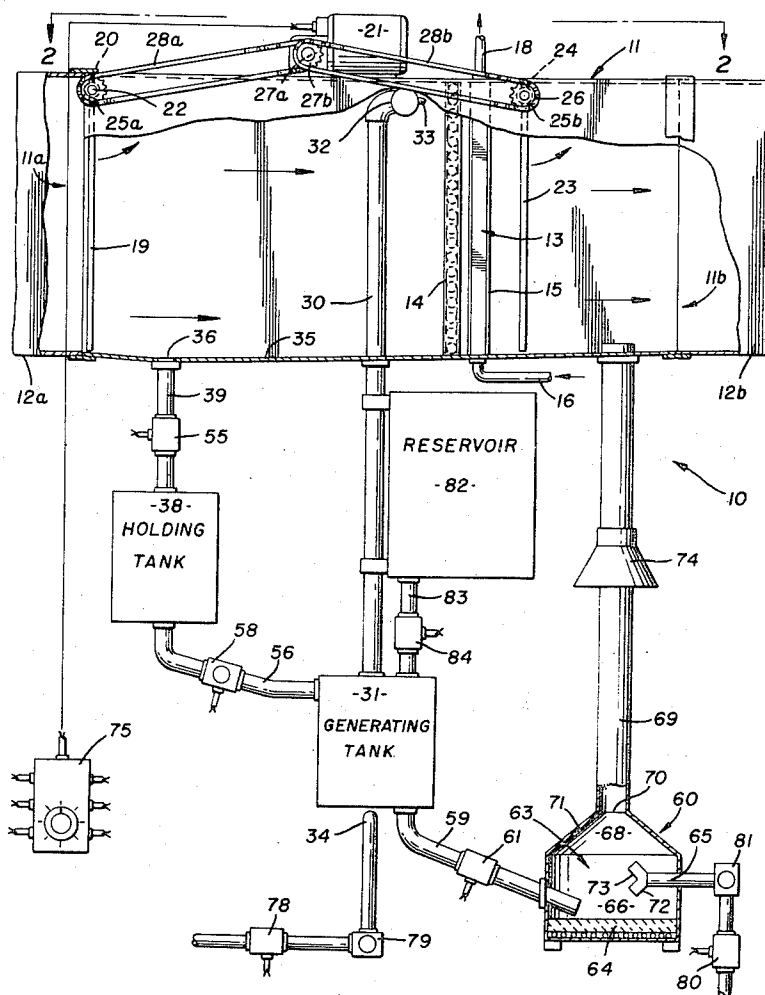
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Primary Examiner—Dennis E. Talbert, Jr.
Attorney—Hamilton, Renner & Kenner

[57] ABSTRACT

An air scrubber for removing and selectively incinerating the condensable contaminants from the exhaust stream of a ventilating system. A generally localized surface area is provided within a collection chamber such that the exhaust stream can flow turbulently therearound and contaminants can condense thereupon. Cooling means may be provided to maintain a temperature differential between the surface area and the exhaust stream in order to facilitate condensation. Gate means are periodically closed to maintain the collection chamber discrete from the remainder of the ventilating system, and while the gate means are closed a cleansing medium directs a cleansing medium across the surface area to remove the accumulated contaminants. The mixture of the cleansing medium and the contaminants is collected and separated so that the cleansing medium may be recycled. The contaminants may then either be collected for removal or conducted into an incinerator where they are received for incineration in a first combustion area. The products of the aforesaid combustion preferably pass through a second combustion area which serves as an after-burner to eliminate substantially all unburned hydrocarbons or other pollutants from the flue gas leaving the incinerator.

4 Claims, 3 Drawing Figures



2 Sheets-Sheet 1

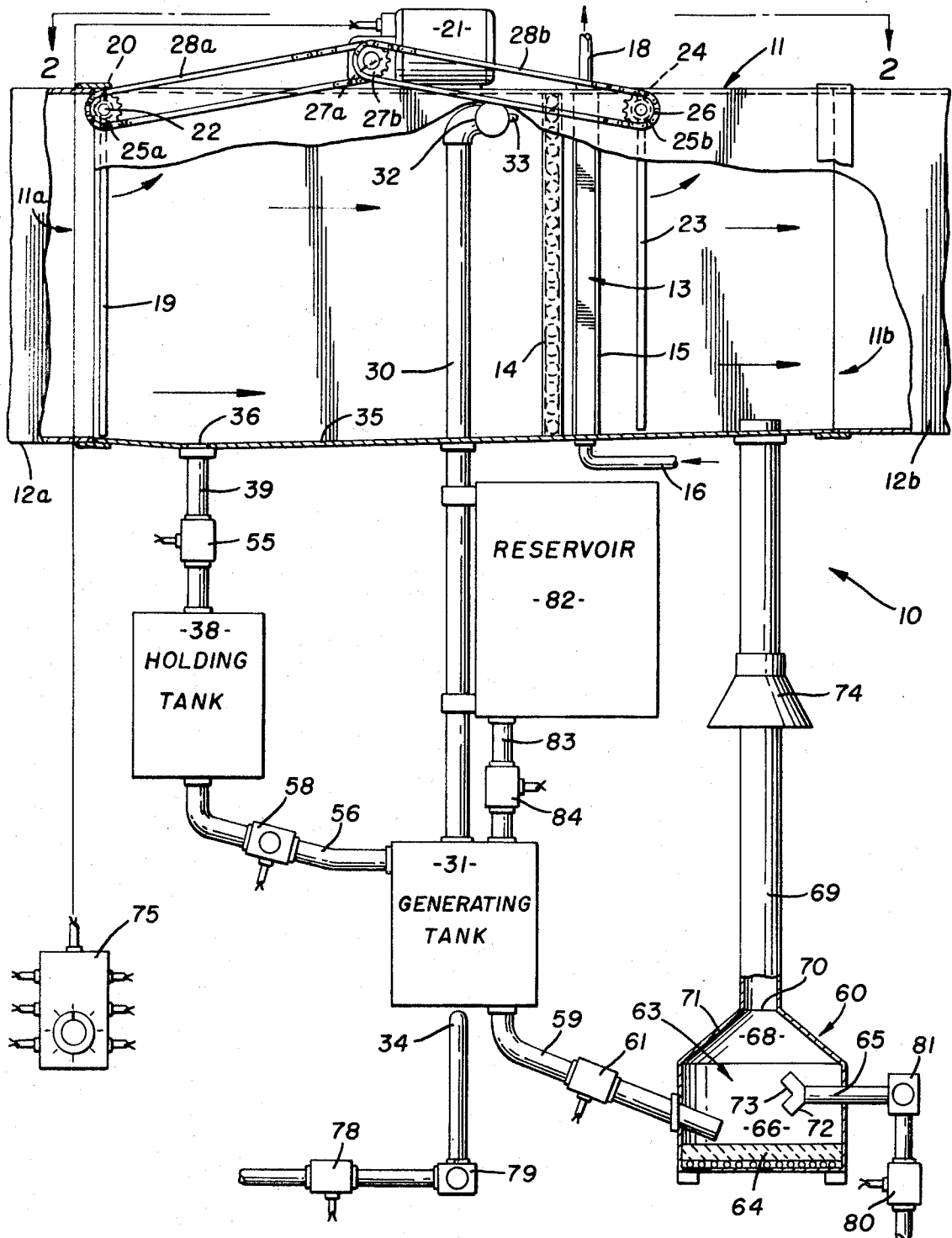


FIG. 1

INVENTOR
 CHARLES D. McNEELY
 BY *Hamilton, Renner*
 & *Renner*
 ATTORNEYS

2 Sheets-Sheet 2

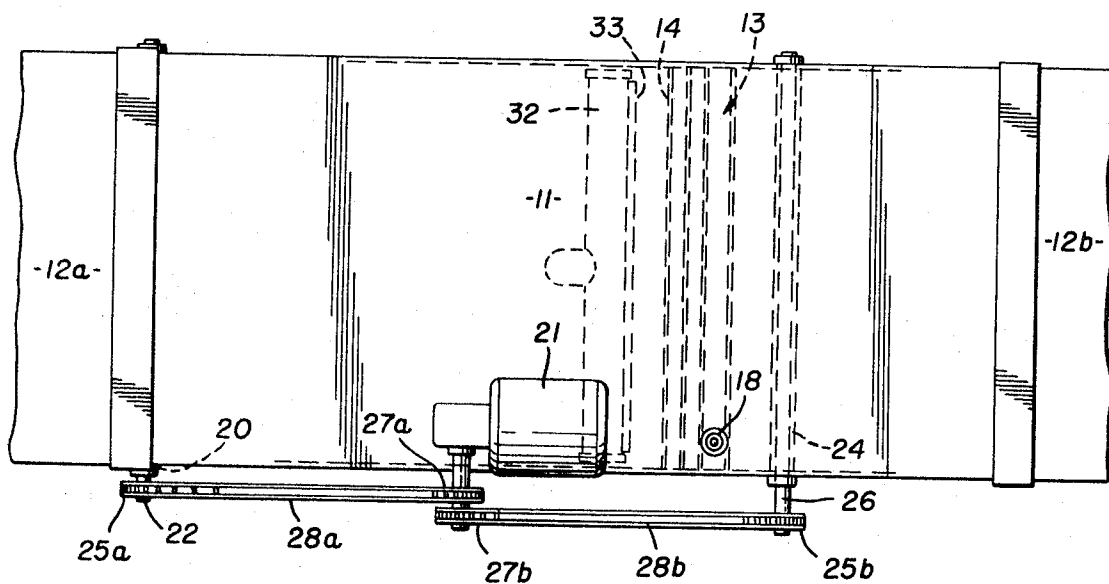


FIG. 2

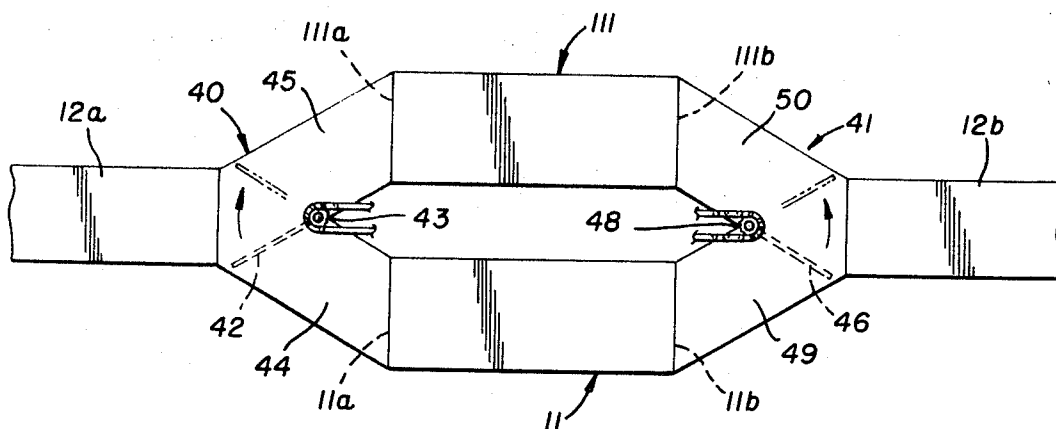


FIG. 3

INVENTOR.
CHARLES D. McNEELY
BY *Hamilton, Renner*
& Kenner
ATTORNEYS

AIR SCRUBBER

BACKGROUND OF THE INVENTION

The present invention relates to the extraction of condensable contaminants such as grease, oil and other flammable materials from the vaporous exhaust stream of a ventilating system before the exhaust stream discharges into the atmosphere. It is the purpose of the present invention to provide a system that not only incorporates a novel concept to extract the contaminants but may also readily and efficiently incorporate means to incinerate the material extracted in order to obviate the emission of undesirable pollutants into the atmosphere.

It is customary to provide forced ventilation systems to remove odors, vapors and heat created while cooking. Such vapors are normally laden with vaporized or entrained fats, greases and oils liberated during the cooking process, particularly from frying units and especially from deep fat frying units. As these vapors are exhausted, the condensable contaminants tend to deposit along the interior of the passages that comprise the ventilating system. These materials are highly flammable and create a significant fire hazard. In fact, fires originating within ventilating systems are particularly dangerous, because they are not readily accessible and can, therefore, cause extensive damage before they can be brought under control.

This same inaccessibility also makes it quite difficult to accomplish the periodic cleaning of the ducts required to alleviate the hazard of fire. As such, many ventilating systems incorporate filters to remove the flammable materials entrained in the exhaust stream. The use of replaceable filters has, to some degree, been successful. Filters provide a compounding of the surface area on which the entrained flammable materials can condense, and, while clean, filters are capable of almost completely removing the flammable contaminants from the exhaust stream. However, the filters must be kept clean. Because it is an unpleasant job to remove and change filters, this task is often unduly postponed. The obvious result of the failure to change filters is the impediment to the passage of the discharge stream therethrough. With the air flow so inhibited smoke tends to accumulate in the cooking area, creating a most unpleasant working environment. Far more insidious is the tendency of the flammable deposit on a dirty filter to revaporize and deposit within the ventilating system at points beyond the filter. The fire hazard can be thus perpetuated with the dirty filter being responsible for the undesirable dissemination of the flammable materials into the more remote reaches of the ventilating system and itself forming a highly vulnerable ignition point.

Some ventilating systems incorporate a series of baffles within the duct work on which to accumulate the flammable deposits, but baffles afford all the drawbacks inherent to dirty filters and, additionally, are not intended to be expendable so that some provision must be made to clean them.

Heretofore, a number of approaches have been propounded to remove the deposit of flammable materials that accumulate within ventilating systems. Most are rather complex, and all require a further means in which to store the contaminants for periodic removal or a further means by which to conduct them into an available sanitary system.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present invention to provide an air scrubber suitable for removing condensable contaminants — particularly the flammable materials — from the vaporous exhaust discharge of a ventilating system.

It is another object of the present invention to provide an air scrubber, as above, which is periodically self-cleaning.

It is yet another object of the present invention to provide an air scrubber, as above, in which the condensable contaminants extracted from the vaporous exhaust discharge may be incinerated.

It is a further object of the present invention to provide an air scrubber, as above, that induces a relatively low pressure drop between the inlet and outlet ends of the system, thereby minimizing the power requirements on the fan, or other device, by which flow through the system is effected.

These and other objects, together with the advantages thereof over existing and prior art forms which will become apparent from the following specification are accomplished by means hereinafter described and claimed.

In general, an air scrubber embodying the concept of the present invention provides a localized accumulating surface on which the contaminants condense. Periodically, a cleansing medium is directed against the surface to remove the accumulated contaminants. The cleansing medium also serves as the vehicle with which the contaminants are collected.

After the mixture of contaminants and cleansing medium are collected, the cleansing medium is separated from the mixture for successive recycling, and the contaminants may either be stored for periodic removal or incinerated.

In method terminology, one can periodically extract condensable contaminants from the exhaust stream of a ventilating system by providing a surface area on which the condensable contaminants can accumulate, applying a cleansing medium to remove the accumulation of contaminants from the surface area, collecting the mixture of cleansing medium and contaminants, separating the contaminants from the cleansing medium to recycle the cleansing medium and disposing of the contaminants, preferably by incineration.

One exemplary embodiment — and an alternative variation thereon — is shown by way of example in the accompanying drawings and described in detail without attempting to show all of the various forms and modifications in which the invention might be embodied; the invention being measured by the appended claims and not by the details of the specification.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic assembly drawing of an air scrubber embodying the concept of the present invention;

FIG. 2 is a schematic top plan of the collection chamber, taken substantially on line 2—2 of FIG. 1; and,

FIG. 3 is a schematic top plan of pair of parallel collection chambers as may be employed in an alternative embodiment of an air scrubber according to the concept of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An air scrubber embodying the concept of the present invention is designated generally by the numeral 10 on the attached drawings. A collection chamber 11 constitutes an elemental component in the duct work 12 of a ventilating system. The ducting 12a leads from a hood or the like (not shown) in the cooking area and communicates with the inlet end 11a of the collection chamber. The ducting 12b communicates between the outlet end 11b of the collection chamber and atmosphere, either directly or through a flue or other terminal ducting. A fan, or other blower, (not shown) is generally mounted within the flue or vent duct to draw the vaporous exhaust into and through the ventilating system.

A filter 13 is secured within the collection chamber 11 and is disposed such that all the exhaust must pass therethrough. A plurality of impingement members 14 are placed adjacent the filter 13 in order to induce turbulent flow at the filter 13 and thereby enhance the contact between the vaporous exhaust and the filter. It has been found that in a collection chamber having a cross-sectional area of approximately 1 square foot, a plurality of 1/2 inch metallic pipe spaced 3/8 inches apart in a plane oriented transversely of the collection chamber cause sufficient turbulence through the filter irrespective of whether they are located upstream or downstream thereof.

To be effective, the filter 13 must present a sufficiently arduous path so as to bring the entire volume of the exhaust flow into contact with the surface area 15 of the filter 13 and yet not overly impede the flow of vaporous exhaust therethrough.

The efficiency with which the contaminant material is extracted from the vaporous exhaust is enhanced by maintaining a marked temperature differential between the surface area 15 of the filter 13 and the exhaust flow. In many installations the desired differential can be assured merely by employing a filter made from a good conductor of heat. For example, a plurality of juxtaposed, expanded metallic sheets afford not only excellent heat dispersion but also present ample surface area without unduly impeding the flow therethrough.

However, in some environments it may be necessary to implement heat dissipation by employing a jacketed filter. That is, one may utilize filter constructed on the order of an automobile radiator and pass a coolant, such as water, therethrough to maintain the desired temperature differential between the filter and the exhaust flow. The filter 13 depicted in FIG. 1 is thus provided with an inlet port 16 and an outlet port 18 through which the coolant serves the jacketed filter.

A pair of closure means are provided selectively to seal the collection chamber 11 from the duct work 12 comprising the remainder of the ventilating system. As shown, a gate 19 may be secured to the inlet 11a of the collection chamber 11, as by hinge 20, and a fractional horsepower motor 21 may be secured to a pintle 22 extending laterally of, and secured to, that portion of the hinge 20 affixed to gate 19. A rotative force applied to pintle 22 by motor 21 selectively swings the gate 19 open, and removal of the rotative force permits the gate to swing closed. Similarly, gate 23 may be secured to the outlet end 11b of the collection chamber 11 as by hinge 24. A sprocket 25a secured to pintle 22 and

a similar sprocket 25b secured to the pintle 26 of the hinge 24 may each be connected to corresponding sprockets 27a and 27b on motor 21 by chain drives 28a and 28b, respectively, so that gate 19 will swing in coincidence with the swing of gate 23.

Pipe 30 constitutes a tubular communicating means by which a cleansing medium is directed into the collection chamber 11 from a receptacle in the form of a generating tank 31. As will become more apparent, the cleansing medium preferably enters the collection chamber 11 in the form of a vapor which, according to the preferred embodiment, is heavier than air. For this reason, the pipe 30 terminates in a lateral header 32 located in the uppermost portion of the collection chamber 11 in proximity to filter 13. A plurality of orifices 33 are provided in spaced relation along the header 32 in order to facilitate distribution of the cleansing medium vapors across the filter.

The cleansing medium may be any material that: is capable of removing accumulated contaminants from a filter on contact; will not erode the filter; and, may be readily separated from the contaminants removed in order to permit recycling. These criteria are fully met by such cleansing mediums as the fluorinated hydrocarbon solvents and the chlorinated hydrocarbon solvents. Such fluorinated hydrocarbon solvents are trichloromonofluoromethane, trichlorotrifluoroethane, tetrachlorodifluoroethane or any mixture thereof. Such chlorinated hydrocarbon solvents are methyl chloroform, methylene chloride, carbon tetrachloride, trichloroethylene or any mixture thereof.

The foregoing solvents have exceptionally advantageous cleansing properties, particularly with respect to the fats, greases and oils liberated during the cooking process. In addition, they leave little or no residue on the surface area cleaned thereby, and they are not injurious to plastics, code markings, most metals and electrical insulating material. However, such solvents are relatively expensive. Nevertheless, an air scrubber embodying the concept of the present invention can be operated with minimal loss of cleansing medium. With a suitable cleansing medium in the generating tank 31 the application of heat energy thereto, as by the heating element 34, will vaporize the cleansing medium and drive it up through the pipe 30 and out the orifices 33 in the header 32. However, before the cleansing medium is vaporized the motor 21 should be actuated to swing gates 19 and 23 into closed position in order to maintain the collection chamber 11 discrete from the ventilating system with which it communicates and thereby preclude loss of the vaporized cleansing medium. As the vaporized cleansing medium comes into contact with the cooler surfaces of the filter 13, impingement members 14 and the interior surfaces of the collection chamber 11 it will condense and remove the accumulated contaminants. When the cleansing medium is a solvent such as the aforementioned fluorinated hydrocarbons or chlorinated hydrocarbons it will dissolve the contaminants and serve as a vehicle in which to collect the contaminants.

As shown in FIG. 1, the base wall, or floor, 35 of the collection chamber 11 slopes to a drain 36 so that the liquid mixture of cleansing medium and contaminants can be collected within the holding tank 38 through a conduit 39 that communicates between the drain 36 and the holding tank 38.

After the mixture of cleansing medium and contaminants has been collected in the holding tank 38 the gates 19 and 23 may be swung open by motor 21 for continued accumulation of contaminants on both the surface area 15 of filter 13 and the impingement members 14. It must be appreciated that the recovery of as much of the cleansing medium as possible is desired with the medium is as expensive as the hydrocarbon solvents designated above. Recovery is enhanced by permitting as much time as possible for the mixture of cleansing medium and contaminants to collect at, and flow through, the drain 36. Desirable recovery may well be assured if the cleaning cycle occurs at a time when the ventilating system can be inoperative for several hours — as, for example, would occur when a ventilating system is turned off at night. However, in those situations where little or no time is available for the ventilating system to be inoperative, extended recovery time can be afforded by providing a second collection chamber 111 which is alternatively included within the ventilating system.

As best seen in FIG. 3, this alternative arrangement may be effected by employing a Y-duct 40 to connect between ducting 12a of the ventilating system and the inlet ends 11a and 111a of the respective collection chambers 11 and 111. A similar Y-duct 41 may be employed to connect the outlet ends 11b and 111b of the respective collection chambers 11 and 111 into the ducting 12b of the ventilating system.

The Y-duct 40 may be provided with a gate 42 mounted at the bifurcation 43 selectively to close branch 44 or branch 45. A similar gate 46 may be mounted at the bifurcation 48 of Y-duct 41 selectively to close branch 49 or branch 50. Co-ordination of gates 42 and 46 in a manner similar to that previously described with respect to gates 19 and 23 will direct the exhaust flow through either collection chamber 11 or 111 and thereby permit them to be alternately cleaned without requiring any discontinuance in the operating of the ventilating system. The gates 42 and 46 not only serve to direct flow but also function to close the selected collection chamber during the introduction of the cleaning medium and thereby obviate the necessity of employing additional gates 19 and 23 within either collection chamber 11 or 111.

Irrespective of whether one or more collection chambers are employed, the capability of closing the communication between the holding tank 38 and the collection chamber associated therewith is considered desirable in order to obviate any possible vaporization of the cleaning medium within the holding tank as a result of the passage of warm exhaust flow through the collection chamber. The employment of valve 55 within conduit 39 affords the desired selectivity of communication. The valve 55 may be closed while the contaminants are accumulating within the collection chamber but would be opened during that time period in which the mixture of cleansing medium and contaminants is being collected.

A conduit 56 connects the holding tank 38 to the generating tank 31 so that the mixture collected in the holding tank can, selectively, flow into the generating tank. The selectivity of this flow may similarly be regulated by valve 58 incorporated within the conduit 56. Valve 58 is preferably maintained in a closed position during the time that heat is being applied to the generating tank 31 to vaporize the cleansing medium therein

and is opened upon completion of the vaporization mode to recharge the generating tank with the mixture in the holding tank. The exact sequence of the preferred method of operation will be hereinafter more fully disclosed.

A further conduit 59 connects the generating tank 31 to a waste receptacle (not shown) or to an incinerator 60 so that one can dispose of the contaminants remaining in the tank after the cleansing medium has been vaporized therefrom either by emptying the receptacle or by incinerating the contaminants. A valve 61 is provided in conduit 59 as selectively to control the exiting flow from the generating tank.

The base of the fire chamber 63 within incinerator 60 is preferably lined with a layer of refractory material 64 to serve as a wick means on which the contaminant materials are deposited as they enter the incinerator 60 through conduit 59. An exemplary refractory material is available from the Carborundum Co. and is sold under the Trademark FIBERFRAX.

Although a heating means in the form of an electric element (not shown) located within, or in proximity to, the wick means may well be employed, in the preferred embodiment depicted a burner 65 extends within the incinerator 60 and directs a flame into a first combustion area 66 defined by the wick means 64 and the air space immediately thereabove. This flame ignites the contaminants on the wick means, and as they burn the products of their combustion rise and pass through a second combustion area 68 at the juncture of the flue 69 and the apex 70 of the cone 71 defining the upper side wall of the fire chamber 63. Means for initiating combustion should also be associated with the second combustion area. This, too, may comprise an electric heating element or a means to direct a flame into that area, and this may also be affected by burner 65. As shown, the head portion 72 of the burner 65 may be split with a baffle wall 73 which directs one portion of the flame into the first combustion area 66 and another portion into the second combustion area 68.

By utilizing a second combustion area, which functions as an after-burner, it has been found that the flue gas leaving the incinerator is almost totally free of any unburned hydrocarbons or other pollutants. It must also be appreciated that for some installations the full benefit of the present invention will be neither required nor desired. As an example, the aspect of the present concept relating to the recovery and recycling of the cleansing medium can be adopted without incorporating the preferred incinerator construction disclosed. One way this might be accomplished would be by utilizing a single heating element in place of the individual heating element 34 and burner 65 and providing means to direct the heat provided by the single element selectively to the generating tank 31 or the incinerator 60.

The flue 69 may connect into the collection chamber 11 on the downstream side of the closed gate 23 with the only requirement being to conform to any code requirements regarding flue gas temperature. A typical code requirement limits the temperature of the flue gas to 500° F. above the ambient room temperature, and this can be quite easily achieved by the use of a barometric damper or a draft diverter bell hood 74, as shown in FIG. 1 and as is well known in the art.

In order fully to understand the operation of an air scrubber 10 embodying the concept of the present invention, it is most convenient to review the operation

of an air scrubber already in operation — i.e., an air scrubber having been previously cycled so that a mixture of cleansing medium and contaminants is available in the generating tank 31.

The first step in the cleansing cycle is to seal the collection chamber from the remainder of the ventilating system. If the installation employs a single collection chamber 11 not only would the gates 19 and 23 be closed but the exhaust fan (not shown) would also be turned off. On the other hand, if multiple collection chambers 11 and 111 are employed, only the gates 42 and 46 need be positioned to prevent the escape of the vaporized cleansing medium about to be admitted to the selected cleansing chamber 11 or 111. The steps may properly be effected by a timer control 75 connected to motor 21 and, if required, the exhaust fan.

With the collection chamber thus sealed, and with the valve 58 — solenoid operated for remote actuation by timer control 75 — closed to preclude communication through the conduit 56 which connects the holding tank 38 to the generating tank 31, the heating element 34 may be actuated to raise the temperature within the generating tank. If, as shown, the heating element 34 is a gas burner, it would be ignited. In a typical installation wherein the generating tank has a capacity of approximately one quart, the burner 34 need only apply about 4,000 B.T.U. in order to vaporize any of the afore-listed preferred cleansing mediums within the generating tank 31 and drive the vapor up through the pipe 30, along the header 32 and out the orifices 33. Although the particular cleansing medium selected will be largely determinative of the time and temperature required to vaporize all the solvent from the mixture within the generating tank 31, in a typical installation wherein the capacity of the generating tank is on the order of one quart, approximately fifteen minutes should suffice.

A valve 78 associated with the burner 34 may be connected to the timer control 75, as may an electric ignition device 79, to turn the burner on and off according to the desired timing sequence of the cleansing cycle.

After the cleansing medium has been fully vaporized, the timer control 75 causes the valve 61 to open and permits the contaminants remaining in the generating tank 31 to flow through conduit 59 and onto the wick means 64 within the incinerator 60. It has been found desirable to open valve 61 as soon as possible after the cleansing medium has been vaporized in order to occasion the flow of the contaminants while they are still warm and before they have had an opportunity to cool and congeal.

The valve 61 is closed after a predetermined time, and the burner 65 ignited. Similarly to burner 34, a valve 80 and an electric ignition device 81 may be employed to turn burner 65 on and off, and they too are preferably actuated by means of the timer control 75.

Continuing with exemplary specifications as to the details of a typical installation, the incinerator 60 may well be a compact arrangement with the fire chamber 63 being approximately three inches in diameter and the distance between the wick means 64 and the apex 70 being approximately six inches. Compatible with an incinerator of that size, the burner 65 need only be rated at approximately 13,500 B.T.U.

As heretofore mentioned, as much time as possible should be permitted for the mixture of cleansing medium and contaminants to collect within the holding

tank 38. As such, the timer 75 should cause the valve 55 in conduit 39 to remain open concurrently with the time afforded for collection of the mixture — i.e., for the entire time during which the collection chamber 11 or 111 is maintained discrete from the remainder of the ventilating system.

At the end of the collection period the timer 75 will actuate the motor 21 so as to renew communication between the collection chamber and the remainder of the duct work comprising the ventilating system. At the same time, the valve 55 (also preferably solenoid operated) will be caused to close.

During the entire portion of the cleaning cycle heretofore outlined, the valve 58 has remained closed, and preferably it should remain closed until just prior to the time that the collection chamber is to be cleaned during the next successive cycle. In that way inadvertent loss occasioned as a result of any residual heat in the generating tank 31 or as a result of warm exhaust air in the collection chamber communicating with the generating tank 31 through pipe 30 can be obviated.

If one follows the preferred procedure, then, the collected mixture of cleansing medium and contaminants will be retained within the holding tank 38 until just prior to the time that the collection chamber is to be cleaned. At the appropriate time the control 75 will cause valve 58 to open, and the collected mixture will flow from the holding tank 38 into the generating tank 31 where it will be retained (the valve 61 being closed) during the subsequent vaporization mode — provision being made for the timer control 75 to close valve 58 after the mixture is received within the generating tank.

Before the vaporizing mode is initiated, however, it is desirable to replenish any of the cleansing medium that may have been lost during the preceding cycle. It must be appreciated that about the only appreciable loss of cleansing medium will be that amount which does not find its way into the holding tank 38 and is retained within the collection chamber. During a typical cycle the amount lost might average approximately 80 milliliters, and that can be replenished from a reservoir 82 which communicates with the generating tank 31 through a conduit 83 containing a metering valve 84 also preferably actuated by timer control 75. The size of the reservoir 82 may be selected in conformity with the amount lost during the cycle and the frequency with which one desires to refill the reservoir.

When the supply of cleansing medium within the generating tank has been replenished, the timer control 75 can effect sealing of the collection chamber, and the cleaning process heretofore described is recycled.

It should now be apparent that an air scrubber embodying the concept of the present invention is well adapted to remove and incinerate the condensable contaminants from the vaporous exhaust discharged on a ventilating system and otherwise accomplish the objects of the invention.

What is claimed is:

1. An air scrubber comprising, a collection chamber, a surface means on which condensable contaminants in the discharge stream of a ventilating system can accumulate, gate means selectively to control the flow of the discharge stream through said collection chamber, a vaporizable solvent capable of dissolving contaminant materials from said surface means, discharge means to direct the vaporized solvent onto said surface means, a holding tank communicating with said collec-

tion chamber to receive and collect the solvent in which the contaminant materials are dissolved, a generating tank, first conduit means by which the contents in said holding tank may be discharged into said generating tank, flow control means operative with respect to said first conduit means selectively to discharge the contents of said holding tank into said generating tank, means to heat said generating tank in order to vaporize the solvent therein and separate it from the contaminant materials dissolved in the solvent, said contaminant materials remaining in said generating tank, second conduit means by which the vaporized solvent passes from said generating tank to said discharge means, an incinerator, third conduit means by which the contaminant materials in said generating tank may be discharged into said incinerator and flow control means operative with respect to said third conduit means selectively to discharge the contaminant materials in said generating tank into said incinerator.

2. An air scrubber, as set forth in claim 1, in which

a reservoir is provided to replenish the supply of solvent in said generating tank, a fourth conduit means connecting said reservoir with a generating tank and metering means operative with respect to said fourth conduit means periodically to introduce a replenishing supply of solvent into said generating tank.

3. An air scrubber, as set forth in claim 1, in which said surface means further comprises a filter located in juxtaposition to a plurality of impingement members.

4. An air scrubber, as set forth in claim 1, further comprising first and second combustion areas in said incinerator means, wick means within said first combustion area to receive the contaminant materials, first burner means to ignite the flammable materials on said wick means and thereby emit products of combustion which pass into and through said secondary combustion area and second burner means to ignite any combustible materials included in the products of combustion emitted from said first combustion area.

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