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(54) **COOKING APPLIANCE AND METHOD OF CONVEYING HEAT ENERGY FROM A COOKING EXHAUST HOOD**

KOCHGERÄT UND VERFAHREN ZUR ÜBERTRAGUNG VON WÄRMEENERGIE AUS EINER DUNSTABZUGSHAUBE

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Description

Cross-Reference to Related Applications

[0001] This patent applications claims the benefit of priority to U.S. Provisional Application No. 60/745,093 for "RECIRCULATING EXHAUST SYSTEM," filed 18 April 2007 and U.S. Provisional Application No. 60/745,276 for "RECIRCULATING EXHAUST SYSTEM," filed 20 April 2007.

Background of the Invention

[0002] Exhaust systems are responsible for a significant loss of energy from industrial and commercial production facilities such as manufacturing facilities, commercial kitchens, laboratories, etc. One of the losses caused by exhaust systems is a result of the withdrawal of significant amounts of conditioned air from the space where contaminants are being produced, which conditioned air must be replaced by conditioning replacement air. Another loss is the energy required to operated exhaust system itself.

[0003] As a result of the recognition of a need to minimize the loss of conditioned air through exhaust systems, various technologies have been proposed. One technique is to minimize the volume of conditioned air that is withdrawn. Some exhaust systems operated under pure potential (also known as laminar) flow conditions such as the hoods used in laboratories. By maintaining potential flow conditions, which inherently requires the use of low velocities, mixing of contaminants with is kept to a minimum. The exhaust system can therefore be very selective

[0004] Another approach that has been applied to reduce the quantity of conditioned air lost through exhaust systems is to try to minimize the total flow based on the conditions. For example, real-time control has been described for commercial kitchens. Examples are US Patents 7048199 for "Kitchen exhaust optimal temperature span system and method" and 6170480 for "Commercial kitchen exhaust system."

[0005] Another approach that has been applied to reduce the quantity of conditioned air lost through exhaust systems is so-called short circuit systems in which make-up air is discharged into the conditioned space close to, or adjacent to, the exhaust hood. The supposed effect of this is to reduce the total volume of conditioned air that must be exhausted while preventing the escape of pollutants into the conditioned occupied space. Examples of such systems are provided by US Patents 4143645 for "Self-contained exhaust hood with heat exchanger and method of exhausting air," 6347626 for "Ventilation system for a kitchen," 4483316 for "Air ventilation system." and 4483316 for "Air ventilation system." These systems, however, because the movement of air is inherently turbulent below the hood and around it, vigorous mixing occurs and hoods. As a result, contaminants enter the conditioned air, often more vigorously because of the turbulence generated by the make-up air discharge, and thus, the exhaust hoods are largely required to exhaust as much conditioned air as in systems where make-up air is introduced remote from the hood.

[0006] In addition to the loss of conditioned air, and the concomitant need to replace the exhausted air by conditioning replacement air, exhaust system may inherently lose energy or materials that would have commercial value if they could be recovered and used. Because of the dilution of the exhaust stream with conditioned air from the hood environment, however, the concentrations and temperatures are such that energy or material recovery is made difficult. In addition, fouling caused by effluent streams is a performance and maintenance problem for energy recovery systems. For example, heat transfer coefficients of surfaces drop quickly as a result of fouling.

[0007] Another issue in the design of exhaust systems is the typical permanence of the configuration once exhaust and utility connections are laid out and installed in a structure. Often it may be desirable to reconfigure a facility such as a commercial kitchen, upgrade appliances and fixtures, or simply relocate equipment. Short circuit exhaust systems offer greater flexibility than those which are connected to outside vents, but utility connections can still pose problems and sometimes short circuit operation is undesirable or impractical in certain facilities.

[0008] Exemplary methods of conveying heat energy and cooking appliances are disclosed in WO 2005/021135 A1 and GB 2 024 392 A.

Summary

[0009] According to the present invention, a method of conveying heat energy defined in claim 1 and a cooking appliance defined in claim 9 are provided.

[0010] The embodiments variously provide features that help to reduce net energy loss in exhaust systems and/or provide for energy recovery.

[0011] According to an embodiment of the invention, a method of conveying heat energy includes filtering exhaust fumes from a cooking exhaust hood, passing filtered exhaust fumes through a heat exchanger and conveying heat therefrom to a heat-consuming process. The filtering includes exposing the exhaust fumes to ultraviolet light to convert olefins in the exhaust fumes to ash. The method further comprises filtering the ash with a disposable filter prior to passing the ultra-violet-filtered flue gas through the heat exchanger.

[0012] According to a preferred embodiment of the invention, the method further comprises using a liquid conveyed through the heat exchanger as a heat source for a heat pump to generate heat at a higher temperature than the liquid. Preferably, the method further includes using the heat exchanger to collect grease. According to the invention, the heat exchanger includes a water spray and the method further comprises directing a UV light toward the disposable filter. Preferably, the heat ex-

changer is a water spray. Preferably, the method includes conveying heat from the heat pump to potable water. Preferably, the method includes, either additionally or alternatively, using heat from the heat pump to pre-heat potable water.

Brief Description of the Drawings

[0013] The accompanying drawings, which are incorporated herein and constitute part of this specification, Illustrate exemplary embodiments and, together with the general description given above and the detailed description given below, serve to explain the features of the invention.

Fig. 1a illustrates a heat exchanger, which may be used as part of a non-venting exhaust device, to cool and clean the effluent stream of a cooking appliance, such as a stove, fryer, or grill.
Fig. 1b illustrates another embodiment of a heat exchanger.
Fig. 1c Illustrates a two stage heat exchanger.
Fig. 1d illustrates another embodiment of a two stage heat exchanger.
Figs. 1e and 1f illustrate multi-stage spray cooling systems.
Fig. 1g illustrates a spray cooling heat exchanger employing a filter element.
Fig. 2a illustrates a self-cleaning heat exchanger system.
Fig. 2b illustrates a dual-loop heat exchanger system.
Fig. 2c illustrates a spray system, similar to that of Fig. 2a, using a heat pump in combination with a spray-type exhaust cooling device, rather than a liquid-air heat exchanger.
Fig. 2d illustrates a spray system, similar to that of Fig. 2b, using a water pre-heating heat exchanginer in combination with a spray-type exhaust cooling device, rather than a liquid-air heat exchanger.
Fig. 2e illustrates a self cleaning heat exchanger system.
Fig. 2f illustrates a self-cleaning heat exchanger and heat recovery system.
Fig. 3a illustrates a heat exchanger that is integrated with a grease extractor.
Fig. 3b illustrates a top view of the heat exchanger and grease extraction filter combination of Fig. 3a.
Fig. 3c illustrates a grease extractor that uses spine fins to enhance the grease extraction performance of the extractor.
Fig. 3d illustrates a combination vortex-type grease filter and heat exchanger.
Figs. 3e and 3f illustrate another embodiment of a combination filter and heat exchanger.
Fig. 4a illustrates the use of ultraviolet light or other ozone generating devices which may be used to cleanse fume-laden air and gases upstream of a heat exchanger.
Fig. 4b illustrates the use of ultraviolet light to help keep a heat exchanger clean.
Fig. 4c illustrates the use of a disposable filter which may keep a heat exchanger clean when used with a grease extractor over cooking appliances such as a stove, fryer or grill.
Fig. 4d illustrates the use of a disposable filter which when used at the outlet of an exhaust system may reduce ambient emissions when used with a grease extractor over cooking appliances such as a stove, fryer or grill.

Detailed Description

[0014] In addition to the fouling problem, there is an opportunity cost and a disposal problem associated with the collection of "waste" heat. The heat collected from the heat exchanger can simply be discarded, for example, by sending consumed cooling water Into a sewer or transferring heat from a coolant to ambient outdoor air using a liquid-air heat exchanger, or by transferring heat to other heat sinks, such as the earth, natural water bodies, cooling towers, etc. The opportunity associated with this disposal problem includes the re-use of the otherwise wasted materials and enthalpy, for example, grease, which can provide a source for biofuels, and heat. Another opportunity is that cleaning exhaust rather than simply sending into the environment, provides environmental benefits.

[0015] One group of applications that motivate the embodiments in the instant specification are those where permanent connection to an exhaust system is either undesirable or impossible. These are so-called closed cycle or recirculating exhaust applications. Another group, which may identify as energy-recovery applications, are those where energy recovery or minimal energy consumption are desired or needed. The two groups are, obviously, not exclusive or coterminous. In systems closed cycle systems, exhaust fumes, which usually include air drawn directly from the surrounding space, may be treated returned to the ambient. This closed cycle may provide an energy recovery effect, such as where a net heat gain is advantageous and the treated fumes serve to heat the ambient air. In energy recovery embodiments, heat may be extracted and used by various means to increase the efficiency of space, water, or other heating applications. Most of the contemplated provide for the substantial removal of contaminants, including heat, before returning exhaust products and air to the, usually-occupied, space.

[0016] One application field is commercial kitchens. Avoiding the installation and updating of permanent exhaust systems, including fans and ductwork, within a structure has many benefits in terms of cost, appearance, flexibility, reliability and other factors. In addition, the thorough recovery and use of waste products has obvious environmental and potential economic benefits.

[0017] Heat may be captured at low temperatures and re-used as a source of preheating by processes that require higher temperatures or as heat sources for a heat pump that lifts the use temperature using a source of power. Sources that can make use of low temperature heat may make use of recovered heat. Also, heat exchanger design can maximize the recovery temperature, for example, use of counterflow heat exchanger configurations may accomplish this.

[0018] Fig. 1a illustrates a heat exchanger, which may be used as part of a non-venting exhaust device, to cool and clean the effluent stream of a cooking appliance, such as a stove, fryer, or grill. A stream of warm or hot effluent 100 which consists primarily of smoke, grease, stream, and air from a cooking process and the surrounding environment passes through an air to liquid heat exchanger 120. A liquid line 140 supplies coolant to the air to liquid heat exchanger 120 and conducts heated coolant away. The cooling of effluent 100 by the liquid heat exchanger 120 and the large surface area of the heat liquid heat exchanger 120 help to precipitate grease particulates and the cooling effect helps to condense water vapor on the cooling surfaces of the heat exchanger. After the effluent 100 passes through the heat exchanger 120, much of the grease and heat has been removed. In a simple embodiment, the source for the coolant may be any suitable cold water supply.

[0019] In the embodiment of Fig. 1a, heat transfer surfaces cool the exhaust stream, reducing enthalpy, thereby removing moisture. At the same time, if grease aerosols and organic vapors are not removed upstream (as they may be according to further embodiments described below), the heat transfer surfaces may cause grease accumulation (impact filtration) and/or condensation of organic vapors. In any case, fouling is a significant problem which may be addressed by various mechanisms including pre-cleaning the exhaust stream before making contact with the heat transfer surface, periodic or continuous cleaning, use of disposable filter or disposable filter surface, use of a regenerating heat transfer surface, and other means. The further embodiments discuss various ways of accomplishing these.

[0020] Fig. 1b illustrates another embodiment of a heat exchanger. In this embodiment, the cooking effluent 100 passes through a water spray 155. The spray 155 cools the exhaust, and may condense water vapor and organic vapors as well as remove particulate pollutants from the effluent stream 100. Water collects in the chamber 150 as runoff and may be disposed of through a drain 145. Surfactants, grease-eating microbes, other compounds may be automatically supplied at intervals from a reservoir, pump, and control valve (for example, as indicated at S) under control of a controller X1. The controller X1 may be configured to add surfactant according to a regular schedule, continuously, or according to a total cumulative load, to the fluid making up the spray 155. This periodic or continuous addition of surfactant may help to carry away grease in the runoff stream through the drain 145. Heat from runoff water may be captured and re-used. Heat capture may be provided by a heat exchanger 151, for example, a fluid circuit built Into the wall as a liner where the runoff accumulates before being discharged through the drain 145. Examples of how captured heat may be used are discussed below.

[0021] Fig. 1c illustrates a two stage heat exchanger. In this embodiment, the effluent 100 first enters a heat reclaim component that includes a heat exchanger 120 with a closed circuit liquid line 130 is used to transfer heat from the liquid-air heat exchanger 120 to another liquid-air heat exchanger 160. The liquid-air heat exchanger 120 removes excess heat from effluent 100 resulting in a partially cooled effluent stream 105. An air to liquid heat exchanger 160 may be used to supply a cooling loop 130 and may also be used to for energy recovery. A second stage cools the effluent stream 105 further resulting in a cooler effluent stream 110. The second stage may employ a second liquid-air heat exchanger 125 whose heat transfer fluid is cooled by chiller 180, for example, a rooftop chiller. Heat may be recovered via closed circuit loop 136 from a desuperheater DS in the chiller to supply heat to a hot water tank HW to handle some portion or all of a hot water load. For example, In a kitchen, the hot water may be used for dishwashing.

[0022] Fig. 1d illustrates another embodiment of a two stage heat exchanger. In a first stage, a primary air to liquid-air heat exchanger 120 pre-cools the effluent down to a first final temperature using a relatively high temperature source of coolant such as a liquid-to-air heat exchanger 160 which cools a liquid coolant in a loop 130 using outdoor ambient air 170. In a second stage, a secondary liquid-air heat exchanger 125 further cools the pre-cooled effluent 105 down to a final temperature using a relatively low temperature source of coolant such from a loop 135 connecting the secondary liquid-air heat exchanger 125 to a chiller 180. The second stage may be replaced with a pure refrigerant loop rather than employing an intermediate liquid coolant as in a split air-conditioning system with a similar effect. As in the previous embodiment, heat may be recovered from a desuperheater to pre-heat or heat water. Alternatively, the heat may be recovered by means of a liquid-refrigerant condensing heat exchanger 186 with a desuperheating component. The may be supplemented by an air refrigerant condensing portion (not shown) to provide a heat sink when the hot water load is low.

[0023] Fig. 1e shows a multi-stage spray cooling system. In this embodiment, the cooking effluent 100 passes into a plenum 141 with multiple spay heads 142 and multiple baffles 143. Runoff from the spray exits through a drain 145, Cleaned 110 air leaves the plenum 141 at an end opposite the Inlet.

[0024] Fig. 1f illustrates a multi-stage spray cooling system. In this embodiment, the cooking effluent 100 may pass through a series of water sprays 195. If the spray 195 is supplied in a spray chamber 190 at a sufficiently cool temperature, the grease may be condensed or come out of suspension in the effluent stream 100 and the stream 110 which exits the system may be both cooler, cleaner, and dryer. A series of spray nozzles (not shown) may spray cold water into the chamber 190. The runoff from spray 155 may be collected in a collection pan 156A and pumped by a pump 154A though a second spray nozzle 155A. The runoff from spray 155A may be collected in a collection pan 156B and pumped by a pump 154B though a third spray nozzle 155B. The runoff from spray 155B may be collected in a collection pan 156C and pumped by a pump 154C though a fourth spray nozzle 155C. The final runoff may be collected through drain 145 for use (as described in the above embodiments or further embodiments below) or may be disposed of.

[0025] In its simplest form, the source for the spray 155 may be a cold water supply. One drawback of this design is that the resulting spray will tend to coagulate and may block the drain lines or coat the inside the spray chamber 150. Detergents, grease-eating microbes, other compounds may be added to the spray 155 to help minimize the problem of grease accumulation In practice. A drain 145 may also be added to drain runoff water. A surfactant may be periodically added to the spray to wash the interior of the chamber as discussed with reference to Fig. 1b. One advantage of this system is that the maximum amount of heat and grease may be removed from the cooking effluent 100 with a minimal amount of water because of the counter-flow effect of the arrangement of nozzles.

[0026] Fig. 2a illustrates a self-cleaning heat exchanger system. In this embodiment the grease laden effluent 100 enters an air-liquid heat exchanger 200 in which the effluent is cooled and cleaned resulting in a clean air stream 205. This embodiment utilizes a heat pump 230, which, in normal operation may provide the cooling loop for the heat exchanger 220. Heat may be rejected from the heat pump via a liquid loop connected to a consumer appliance that requires high input temperatures, such as a hot water heater 250. The latter could also be a dishwasher, food warmer, or other appliance which may be found in a commercial kitchen. Reclaimed heat may be so used in any of the embodiments described herein. Reclaimed heat can also be used for pre-heating a fluid such as potable water supplied to a water heater or water provided for dishwashing.

[0027] The heat pump cycle may be reversed to provide a temporary heating effect to the heat exchanger 220 which may be used to melt accumulated grease from the heat exchanger surface. The temporary heating effect may be provided when the fume load is low or zero. For example, the fume generating appliance may provide a signal indicating current or future load which may be used to control the application of heating effect. Some batch-type appliances, such as batch fryers, operate on a regular schedule, so controlling to automate the heat pump reverse cycles presents a straightforward control problem, once the task is defined. Most grease filtering devices are provided with a grease collection system. So the embodiment contemplated in connection with Fig. 2a would have a conventional grease collection system configured to collect grease that falls from the heat exchanger (evaporator/condenser coil).

[0028] Note that in addition to the above, the embodiment of Fig. 2a may also be equipped with a spray device to clean the heat exchanger periodically to ensure that any grease that does not drip from the heat exchanger during the reverse (heating) cycle will still be removed. This will help to ensure good heat transfer performance. See Fig. 2f, and attending discussion, for a configuration that provides cleaning. The cleaning cycle can also be controlled to occur automatically during non-operating periods based on a timer or based on input from fume generating equipment. In another alternative embodiment, instead of pumping heat from the air-liquid heat exchanger 220 to a hot water heater 250, the heat can be rejected to a heat sink such as outdoor air as In the embodiment of Fig. 2e, described below. In addition, the air-liquid heat exchanger can, in yet another embodiment, be part of a refrigerant loop.

[0029] As part of a non-recirculating hood system, an ultra-compact heat pump may be preferred. For example, an absorption-type device such a described in US Patent No. 5,611,214. Such a system may use heat from a heat source that converts the fuel of the heat source to heat, or may extract high temperature heat from the heat source using a heat exchanger attached to the appliance. The heat pump may also obtain high temperature heat from a heat source, such as a waste heat source, other than the fume generating appliance. For example, heat could be collected from an oven vent.

[0030] Fig. 2b illustrates a dual-loop heat exchanger system. This embodiment is similar to that of Fig. 1a, but the source of coolant water is a water preheater that provides fresh preheated water to a hot water heater or storage hot water heater or storage tank 250. As in the embodiment of Fig. 2a, the device indicated at 250 may be a preheated storage tank for use with a tankless water heater or a hot water heater. An intermediate heat exchanger 240 provides an additional layer of security against contaminant breakthrough. The liquid-liquid heat exchanger transfers heat between the air liquid heat exchanger 220 and the hot water heater or storage hot water heater or storage tank 250.

[0031] Effluent 200 enters a heat exchanger 220 where the effluent is cooled and cleaned resulting in a cleaned effluent stream 205. The Fig. 2b embodiment may be controlled so that coolant is pumped only when there is sufficient heat available to raise the water temperature. Heat may be conveyed to a heat exchanger in a hot water tank or to a fresh water inlet line so that the tank is filled as heat is added. In the latter case, a predictive controller may optimize for the preheating of water by postponing the addition of water to the tank until heat is available from the flue gas 200, since the waste heat load may be highly variable. In an embodiment, the hot water heater may an instant hot water type water heater (also known as a tankless water heater). In that case, the device 250 may simply be an inline insulated storage tank that stores water (and pre-heat) temporarily, providing as much pre-heat as available. In the latter case, water would be stored . Note that spray wash-cleaning of the cooled heat exchanger may be provided as in other embodiments discussed herein. Note that instead of the intermediate heat exchanger 240, a single double-wall heat exchanger may be provided to exchange heat between fresh water and the flue gas in the component indicated at 220.

[0032] Fig. 2c illustrates a spray system, similar to that of Fig. 2a, using a heat pump in combination with a spray-type exhaust cooling device, rather than a liquid-air heat exchanger. Fig. 2d illustrates a spray system, similar to that of Fig. 2b, using a water pre-heating heat exchanginer in combination with a spray-type exhaust cooling device, rather than a liquid-air heat exchanger. Runoff from the spray chambers 235 is recirculated back to the heat exchanger 240 to be cooled again. As in other embodiments, surfactant may be periodically added to the spray to wash the interior of the chamber. Outgoing 247 and return 246 lines are provided in both the Fig. 2c and 2d embodiments. In other respects, these two embodiments are the same as described with reference to Figs. 2a and 2b, respectively.

[0033] Referring to Fig. 1g, in an alternative embodiment, a spray type cleaner and/or heat exchanger 204 is used in conjunction with a filter 202, such as a metal mesh or screen filter of the type commonly used as a prefilter in air conditioning systems. Such filters are known and made in various ways, for example, by multiple layers of perforated sheet metal forming tortuous passages. Water (or water plus surfactant) is sprayed by one or more nozzles 206 in a chamber 208 housing the filter and effluent flows through the filter 202. Water may be recovered and recirculated after transferring heat to a liquid heat exchanger (not shown) or disposed of if the application is only for cleaning.

[0034] The chamber 208 defines a collection area for collecting the liquid sprayed into the chamber 208." The collected liquid may be conveyed back to the nozzle 206 or disposed of, in alternative embodiments. In a preferred embodiment, the collected liquid is passed through a heat exchanger to recover heat transferred to the liquid from the flue gas. Also, or alternatively, in a preferred embodiment, the spray type cleaner and/or heat exchanger 204 of Fig. 1g is employed in a short-circuit exhaust system in which flue gas is cleansed by the spray type cleaner and/or heat exchanger 204 and conveyed back into the occupied space as shown in the embodiments below.

[0035] Fig. 2e illustrates a self cleaning heat exchanger system. In this embodiment, the grease-laden effluent 200 enters a heat exchanger 221 where the effluent may be cooled and cleaned to produce a processed effluent stream 205. A cooling loop, including a heat exchanger 221, is cooled by a heat pump 230. The cooling loop chills the heat transfer surfaces of the heat exchanger 221. The heat pump 230 may be configured to drive the temperature of the heat exchanger 221 heat transfer surfaces to the point of freezing water.

[0036] Referring now also to Fig. 2f, the heat transfer surfaces 232 (typ.) of the heat exchanger 221 may be configured to freeze water on them, as do automatic ice makers. During low or no load cycles, the spray 234 may spray water on the heat exchange surfaces 232 to form layers of ice thereon. The ice surface can be used to cool the effluent stream and condense gaseous organics as well as act as a surface for attracting aerosol grease.

[0037] If the cold surface of the heat transfer surfaces 232 is maintained at a cold enough temperature, the water can remain frozen even while the hot exhaust fumes pass through the heat exchanger 221, though this is not essential. The purpose of the ice is to act as a shield to protect against grease accumulating on the heat transfer surfaces 232. The ice can be melted and regenerated during zero or low load portions of a cooking process cycle. The melting process can be augmented by reversing the heat pump 230. In addition, the during the ice-melting cycle, a controller X2 may add surfactant S to the water spray to help wash out grease that adheres to the heat exchange surfaces 232.

[0038] The heat pump 230 may be controlled by a controller X3 to heat the heat transfer surfaces 232 to a high enough temperature to melt all the ice. Then the washing spray can be applied and drained through drain 237. The heat pump 230 can be further controlled to continue to heat the surfaces 232 to a point where any solidified grease melts from the surfaces.

[0039] In an alternative embodiment, the heat pump 230 can reject heat to a temporary hot or warm water store that preheat tap water and stores it in a storage container 239. Controller X2 may selectively control a control valve V to add the warmed water for melting the ice, solidified grease, and for washing the heat transfer surfaces. In this case, the heat pump may or may not need to operate in a reverse mode.

[0040] One drawback of this system is that the air to liquid heat exchanger 220 will require periodic cleaning to remove any accumulated grease which builds up on the surface. An advantage of this system is that the heat pump 230 may run in a reverse cycle which may provide heating to the heat exchanger 221 which may melt and drain off any accumulated grease present.

[0041] Fig. 3a illustrates a heat exchanger 350 that is integrated with a grease extractor 360 to both cool the effluent stream and improve the grease extraction performance of the extractor. The design of the grease extraction portion 360 may follow designs disclosed in 4,872,892 (Vartiainen, et al.) which is hereby incorporated by reference as fully set forth in its entirety herein. In the filter portion 360 the grease laden effluent stream from the cooking process enters the grease extractor 360 as shown by arrows 370. The effluent is cooled upon contact with the filter surfaces. In addition, grease aerosols that solidify on the surface may tendency to be re-entrained.

[0042] Cooler and cleaner air 380 may exit the grease extractor 360 through its ends. The heat exchanger 350 may be positioned against the back of the grease extractor 360 which may provide a cooler surface temperature. The cooling source for the heat exchanger 350 may be a liquid line which may utilize water, a phase change refrigerant, or another coolant fluid. An exemplary operating temperature is in the range of 33 to 36 degrees Fahrenheit range, which will condense grease and water vapor, but not freeze water.

[0043] Fig. 3b illustrates a top view of the heat exchanger and grease extraction filter combination of Fig. 3a. Grease laden effluent 370 from the cooking process enters the grease extractor 320 as indicated by arrows 370. Channels for the heat transfer fluid 353 conduct heat from fins 315 and the back surfaces 354 of the vortex chambers 351. The effluent cools upon contact with the filter surfaces within vortex chambers 351.

[0044] Fig. 3c illustrates a grease extractor that uses spine fins 385 to enhance the grease extraction performance of the extractor 360. In this embodiment a filter 375 generally configured as filter the one previously indicated at 360 (Fig. 3a) has a spine-finned heat exchanger 386 with a heat pipe 387 conveying heat to a header 365 that conveys coolant. Effluent 370 enters the filter 375 and collects on the filter walls and the fins. The cleansed effluent 380 leaves the filter 375 in the same manner as the filter embodiment of Figs. 3a and 3b. The spine-finned heat exchangers 386 may be removed periodically for cleaning.

[0045] Referring now to Fig. 3d, an embodiment of a finned-tube heat exchanger 395 integrated with a vortex-type grease filter 380 is shown. The fins are illustrated as cylindrical volumes, indicated at 382, which show the space occupied by the fins collectively. Collectively, the fins form a brush-like heat transfer inserts 392 and are connected to convey heat to/from a centrally located heat pipe 388 which runs into a header tube 384. The heat pipe may adopt a serpentine shape as indicated at 386 or have another type of heat transfer augmentation such as fins to transfer heat to a fluid medium carried by the header tube 384. As illustrated, each heat pip 388 is connected to two heat transfer inserts, but other configurations are possible as will be apparent to those skilled in the art. A quick-connector 393 and 394 may be provided to connect a pipe or another header tube indicated at 390.

[0046] To assemble, the heat transfer inserts 392 are slid into the vortex chamber exits 396. To disassemble, the heat transfer inserts 392 are extracted from the vortex chamber exits 396. The vortex-type grease filters 380 can be removed with the heat transfer inserts 392 in place. Since the heat transfer medium that flows through the header tube 384 may be a low pressure circuit (and even if not) the connectors 392 and 394 may be pressure fit connectors. In addition, the entire heat exchanger 395 unit may be made as a multiple-use disposable unit.

[0047] Referring now to Figs. 3e and 3f, a combination heat exchanger and grease filter 440 has zigzag shaped fins 444 which force effluent running across the fins through a tortuous path when the effluent stream is appropriately conveyed through the filter 440, as shown in Fig. 3f. A heat transfer fluid is distributed and recovered through headers 441 and 442. Multiple heat transfer tubes 446 connect the headers 441 and 442 and receive heat energy by conduction through the fins 444. The filter 440 can be arranged in a ducting component or system, at least a portion of which is shown at 456, such that effluent traverses the fins and liquid precipitate 452 is collected from the ducting 456. In a particular embodiment, spray nozzles 448 spray water, or water plus a surfactant, onto the fins 444. The spray liquid may be recovered and used as a heat transfer fluid, recirculated or partially recirculated. The orientation of the filter 440 and the particular shapes of the fins 444 can be such that grease 452 can flow to a collection area. For example, the shape of the fins 444 can define troughs through which the grease runs and the housing 446 can further define collection paths for the grease.

[0048] Fig. 4a illustrates the use of ultraviolet light or other ozone generating devices which may be used to cleanse fume-laden air and gases upstream of a heat exchanger. The embodiments shown in Fig. 4a to 4d include mechanisms for cleaning the heat exchanger or reducing the quantity of fouling products from reaching the heat exchanger surfaces. In these embodiments, grease laden exhaust stream 400 first passes through a grease extraction filter 420 whereby larger particulates are removed from the air stream.

[0049] After the exhaust stream exits the primary grease extractor 420, it is exposed to UV light 430. The UV light 430 is preferably directed toward the surface of the heat exchanger 410 which may help to prevent grease from accumulating on the heat exchanger surface. Ultraviolet lamps may be available in two broad categories: ozone producing and non-ozone producing. Ozone producing lamps may provide the benefit of oxidizing the grease into other compounds by reacting with grease molecules in the exhaust air 400. One drawback of utilizing ozone producing lamps is that the ozone may need to be removed. Methods which may be used for removal of ozone are described later in this document.

[0050] Fig. 4b illustrates the use of ultraviolet light to help keep a heat exchanger clean. when used with a grease extractor over cooking appliances such as a stove, fryer or grill. Fig. 4b is similar to the previous embodiment but adds a disposable filter 440 into the system. In this embodiment the disposable filter 440 may be used as a means of extracting grease prior to the grease reaching the heat exchanger 410. UV light 430 may be used in this embodiment to maybe keep the disposable filter 440 clean, whereby it's useful life may be extended and in practice it may not have to be replaced as often as a system which may not use ultraviolet light 430.

[0051] Fig. 4c illustrates the use of a disposable filter which may keep a heat exchanger clean when used with a grease extractor over cooking appliances such as a stove, fryer or grill. In this embodiment the grease laden air 400 from a cooking process enters the primary grease extractor 420, at which point significant amounts of grease particulate may be removed from the air stream. Additionally, if the grease extractor is at a sufficiently cool temperature, some of the grease vapor may condense out on the grease extractor 340 surfaces. After the air exists the grease extractor 420 it may be further cleaned by a disposable filter 440. The filter may be manufactured from paper, plastics, or other materials. The disposable filter 440 may furthermore be of the HEPA variety (which has a particulate removal efficiency of 99.97% at 0.3 micron particle size) or ULPA filter variety (classified as removing 99.999% of 0.1 to 0.2 micron particulates). The results is that a much cleaner air stream meets the air to liquid heat exchanger 410 which may results in better heat transfer performance and may cool the entering air. The air stream 405 leaving the system may be cleaner and cooler than the entering air stream 400. One advantage of this system is maintenance and cleaning costs may be reduced through the use of a disposable filter 440 due to reduced labor expenses.

[0052] Fig. 4d illustrates the use of a disposable filter which when used at the outlet of an exhaust system may reduce ambient emissions when used with a grease extractor over cooking appliances such as a stove, fryer or grill. This embodiment has similar performance to the previous embodiment but may be used to reduce ambient emissions further after the grease extractor 420 and the heat exchanger 420 provide an initial degree of purification. In this embodiment the grease laden air 400 enters the system, passes through a primary grease extractor 420 which may remove particulate matter from the air stream. The air may then be cooled by contact with a heat exchanger 410 which may further reduce the amount of grease remaining in the air stream. Finally the air stream enters a disposable filter 440 which may be manufactured form paper, plastics, or other materials. The air which is exhausted from the system 405 may be cleaner and cooler than the air which enters the system 400.

[0053] Note that in the embodiments of Figs. 4a to 4d, the heat exchanger components 410 can also represent any of the heat exchanger embodiments discussed in the instant specification.

[0054] A first aspect of an embodiment of the present invention is a method of conveying heat energy, comprising: filtering exhaust fumes from a cooking exhaust hood; passing filtered exhaust fumes through a heat exchanger and conveying heat therefrom to a heat-consuming process,

[0055] A further preferred embodiment is a method of conveying heat energy, comprising: spraying water into a chamber through which exhaust fumes from a cooking exhaust hood are conveyed; collecting water heated by the exhaust fumes and transferring the heat therein using a heat exchanger. Said water may contain a surfactant.

[0056] A further preferred embodiment of the present invention is a method of conveying heat energy, comprising: using a liquid conveyed through the heat exchanger as a heat source for a heat pump to generate heat at a higher temperature than the liquid.

[0057] In a further aspect of the preferred embodiment of the present invention, said method further comprises using the heat exchanger to collect grease.

[0058] In a further aspect of the preferred embodiment of the present invention, said heat exchanger includes a water spray.

[0059] In a further aspect of the preferred embodiment of the present invention, said heat exchanger is a water spray.

[0060] In a further aspect of the preferred embodiment of the present invention, said method further comprises conveying heat from the heat pump to potable water.

[0061] In a further aspect of the preferred embodiment of the present invention, said method further comprises using heat from the heat pump to pre-heat potable water.

[0062] While the present invention has been disclosed with reference to certain embodiments, numerous modification, alterations, and changes to the described embodiments are possible without departing from the scope of the present invention, as defined in the appended claims. Accordingly, it is intended that the present invention not be limited to the described embodiments, but that it has the full scope defined by the following claims.

Claims

1. A method of conveying heat energy, comprising:

filtering exhaust fumes from a cooking exhaust hood;
passing filtered exhaust fumes through a heat exchanger (410); and
conveying heat therefrom to a heat-consuming process, wherein the filtering includes exposing the exhaust fumes to ultraviolet light (430) to convert olefins in the exhaust fumes to ash, **characterised in that** the method further comprises filtering the ash with a disposable filter (440) prior to passing the ultra-violet-filtered flue gas through the heat exchanger (410),
wherein the heat exchanger (410) includes a water spray, and
the method further comprising directing a UV light (430) toward the disposable filter (440).

2. The method of claim 1, wherein the UV light is ozone producing.

3. The method of claim 1, wherein the UV light is non-ozone producing.

4. The method of claim 1, further comprising: using a liquid conveyed through the heat exchanger as a heat source for a heat pump to generate heat at a higher temperature than the liquid.

5. The method of claim 4, further comprising using the heat exchanger to collect grease.

6. The method of claim 4, wherein the heat exchanger is a water spray.

7. The method of claim 4, further comprising conveying heat from the heat pump to potable water.

8. The method of claim 4, further comprising using heat from the heat pump to pre-heat potable water.

9. A cooking appliance with a grease extraction filter (420) thereabove to be firstly passed by a grease laden exhaust stream (400), and, after the grease extraction filter (420), with a UV light (430), to which the exhaust stream is exposed after the exhaust stream exits the grease extractor filter (420), and, after the UV light (430), with a disposable filter (440), which is to be passed by the exhaust stream (400) after the exhaust stream exists the UV light (430) and which extracts grease, and, after the disposable filter (440), with a heat exchanger (410), to be passed by the exhaust stream (400) after the exhaust stream (400) exists the disposable filter (440), wherein
the heat exchanger (410) includes a water spray, and the UV light (430) is directed toward the disposable filter (440).

Patentansprüche

1. Verfahren zum Transportieren von Wärmeenergie, aufweisend:

   Filtern von Abgasen aus einer Kochdunstabzugshaube,
   Passieren der gefilterten Abgase durch einen Wärmetauscher (410), und
   Transportieren von Wärme daraus zu einem wärmeverbrauchenden Prozess, wobei das Filtern das Aussetzen der Abgase einem ultraviolettem Licht (430) aufweist, um Olefine in den Abgasen in Asche umzuwandeln,
   dadurch gekennzeichnet, dass das Verfahren ferner das Filtern der Asche mit einem Einwegfilter (440) vor dem Passieren des ultraviolett-gefilterten Abgases durch den Wärmetauscher (410) aufweist,
   wobei der Wärmetauscher (410) einen Wassersprühnebel aufweist und
   das Verfahren ferner das Richten eines UV-Lichts (430) in Richtung zu dem Einwegfilter (440) aufweist.

2. Verfahren gemäß Anspruch 1, wobei das UV-Licht ozonerzeugend ist.

3. Verfahren gemäß Anspruch 1, wobei das UV-Licht nicht ozonerzeugend ist.

4. Verfahren gemäß Anspruch 1, ferner aufweisend das Verwenden einer durch den Wärmetauscher transportierten Flüssigkeit als Wärmequelle für eine Wärmepumpe, um Wärme mit einer höheren Temperatur als die Flüssigkeit zu erzeugen.

5. Verfahren gemäß Anspruch 4, ferner aufweisend das Verwenden des Wärmetauschers, um Fett zu sammeln.

6. Verfahren gemäß Anspruch 4, wobei der Wärmetauscher ein Wassersprühnebel ist.

7. Verfahren gemäß Anspruch 4, ferner aufweisend das Transportieren von Wärme von der Wärmepumpe zu Trinkwasser.

8. Verfahren gemäß Anspruch 4, ferner aufweisend das Verwenden von Wärme aus der Wärmepumpe, um Trinkwasser vorzuwärmen.

9. Kochvorrichtung mit einem Fettextraktionsfilter (420) darüber, um zunächst von einem fettbeladenen Abgasstrom (400) passiert zu werden, und nach dem Fettextraktionsfilter (420) mit einem UV-Licht (430), dem der Abgasstrom ausgesetzt wird, nachdem der Abgasstrom aus dem Fettextraktionsfilter (420) austritt, und nach dem UV-Licht (430) mit einem Einwegfilter (440), der von dem Abgasstrom (400) zu passieren ist, nachdem der Abgasstrom aus dem UV-Licht (430) austritt, und der Fett extrahiert, und nach dem Einwegfilter (440) mit einem Wärmetauscher (410), um von dem Abgasstrom (400) passiert zu werden, nachdem der Abgasstrom (400) aus dem Einwegfilter (440) austritt, wobei

   der Wärmetauscher (410) einen Wassersprühnebel aufweist und
   das UV-Licht (430) in Richtung zu dem Einwegfilter (440) gerichtet ist.

Revendications

1. Procédé de transport d'énergie thermique, comprenant :

   le filtrage des fumées d'échappement d'une hotte aspirante de cuisine ;
   le passage des fumées d'échappement filtrés à travers un échangeur de chaleur (410) ; et
   le transport de la chaleur à partir de celui-ci jus-

qu'à un processus consommateur de chaleur, dans lequel le filtrage inclut l'exposition des fumées d'échappement à une lumière ultraviolette (430) pour convertir les oléfines dans les fumées d'échappement en cendre,
caractérisé en ce que le procédé comprend en outre
le filtrage de la cendre avec un filtre jetable (440) avant de faire passer le gaz de combustion filtré par ultraviolets à travers l'échangeur de chaleur (410),
dans lequel l'échangeur de chaleur (410) inclut une pulvérisation d'eau, et
le procédé comprenant en outre l'orientation d'une lumière UV (430) vers le filtre jetable (440).

2. Procédé selon la revendication 1, dans lequel la lumière UV produit de l'ozone.

3. Procédé selon la revendication 1, dans lequel la lumière UV ne produit pas d'ozone.

4. Procédé selon la revendication 1, comprenant en outre : l'utilisation d'un liquide transporté dans l'échangeur de chaleur en tant que source de chaleur pour une pompe à chaleur afin de générer de la chaleur à une température plus élevée que le liquide.

5. Procédé selon la revendication 4, comprenant en outre l'utilisation de l'échangeur de chaleur pour recueillir des graisses.

6. Procédé selon la revendication 4, dans lequel l'échangeur de chaleur est une pulvérisation d'eau.

7. Procédé selon la revendication 4, comprenant en outre le transport de chaleur de la pompe à chaleur jusqu'à de l'eau potable.

8. Procédé selon la revendication 4, comprenant en outre l'utilisation de la chaleur de la pompe à chaleur pour préchauffer de l'eau potable.

9. Appareil de cuisson avec un filtre d'extraction des graisses (420) au-dessus de celui-ci destiné à être tout d'abord traversé par un flux d'échappement (400) chargé en graisses, et, après le filtre d'extraction de graisses (420), avec une lumière UV (430), à laquelle le flux d'échappement est exposé après que le flux d'échappement sort du filtre extracteur de graisses (420), et, après la lumière UV (430), avec un filtre jetable (440), qui est destiné à être traversé par le flux d'échappement (400) après que le flux d'échappement sort de la lumière UV (430) et qui extrait les graisses, et, après le filtre jetable (440), avec un échangeur de chaleur (410), destiné à être traversé par le flux d'échappement (400) après que le flux d'échappement (400) sort du filtre jetable (440), dans lequel
l'échangeur de chaleur (410) inclut une pulvérisation d'eau, et
la lumière UV (430) est orientée vers le filtre jetable (440).

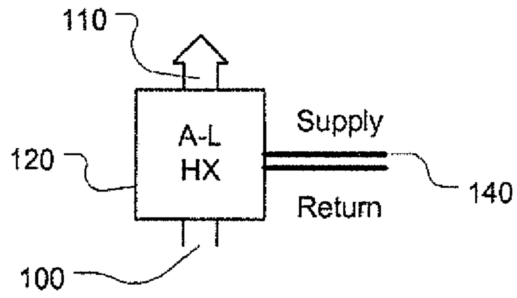

FIG 1a

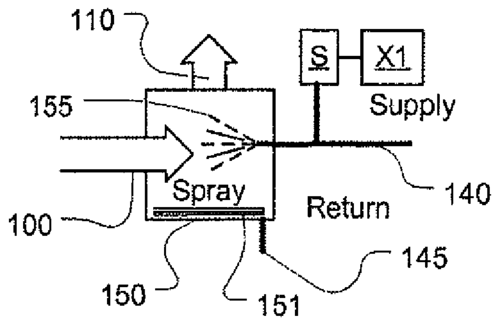

FIG 1b

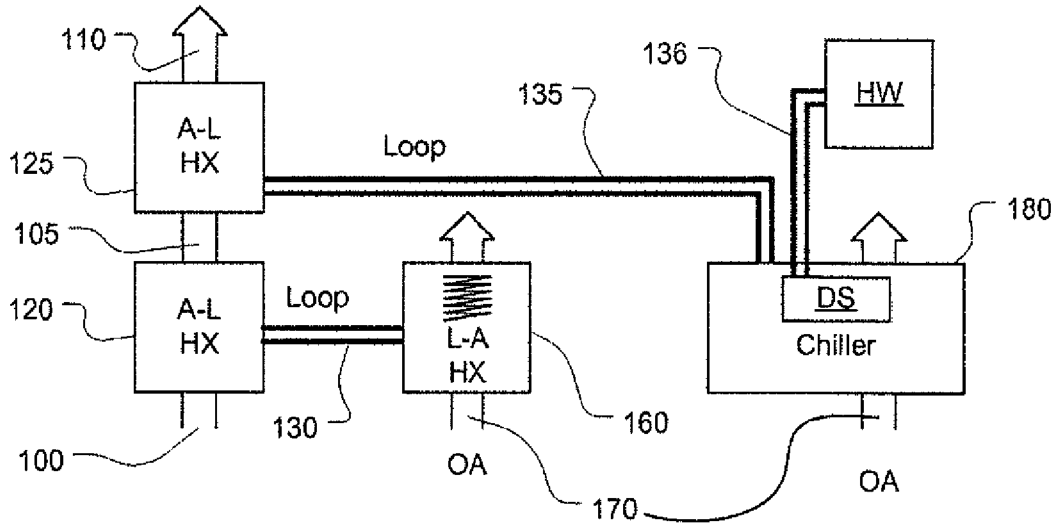

FIG 1c

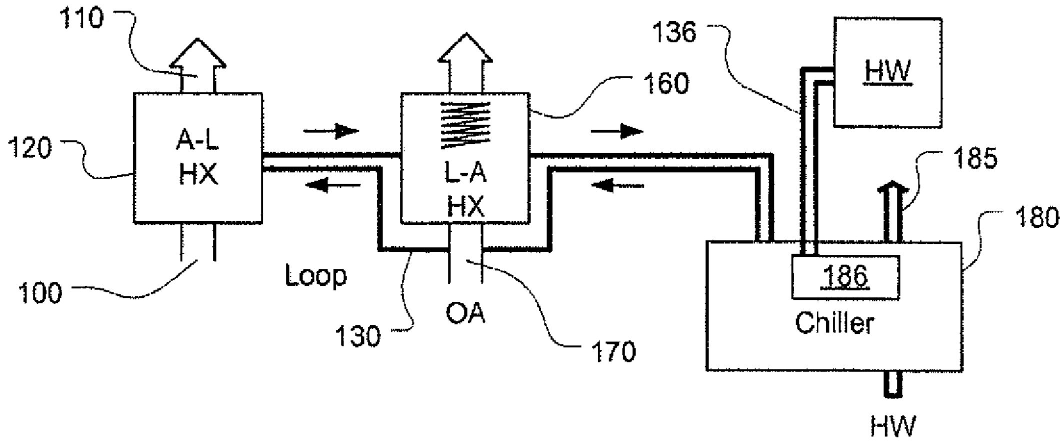

FIG 1d

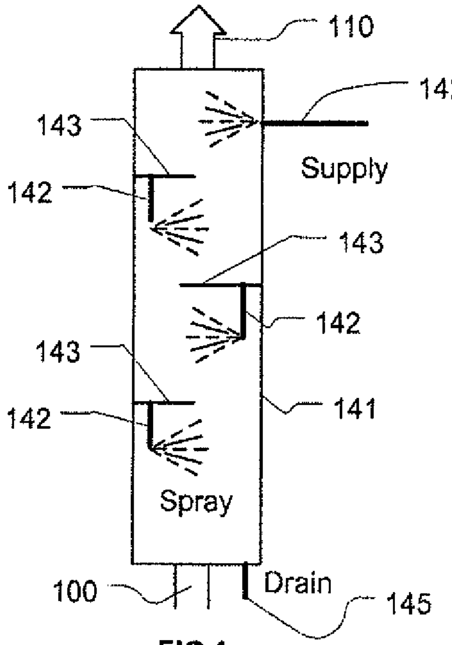

FIG 1e

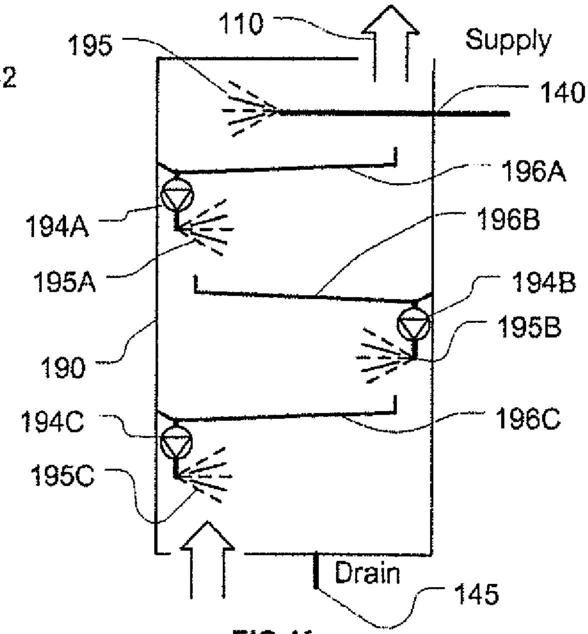

FIG 1f

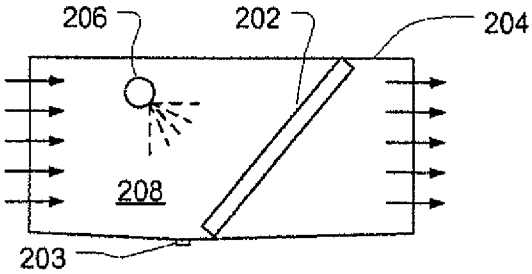

FIG 1g

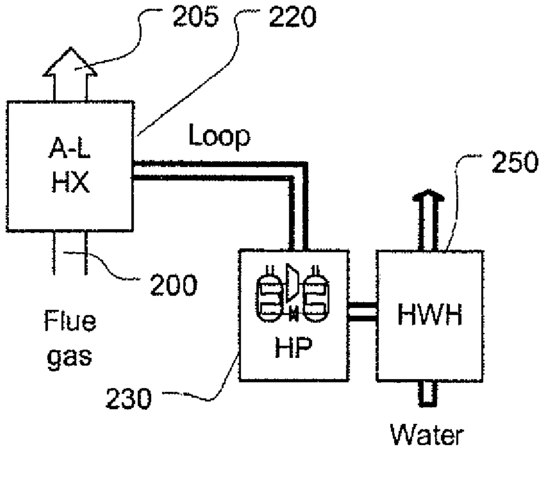

FIG 2a

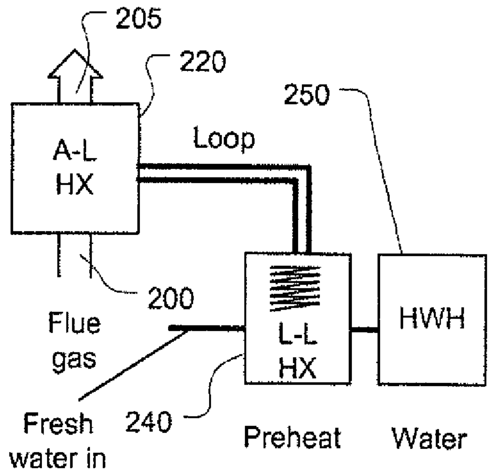

FIG 2b

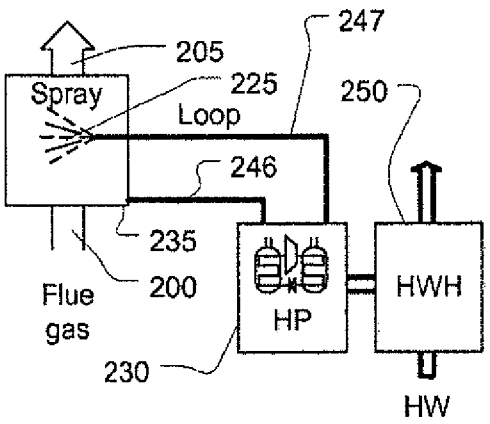

FIG 2c

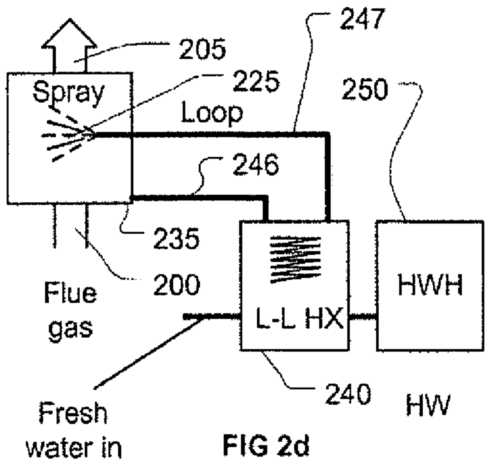

FIG 2d

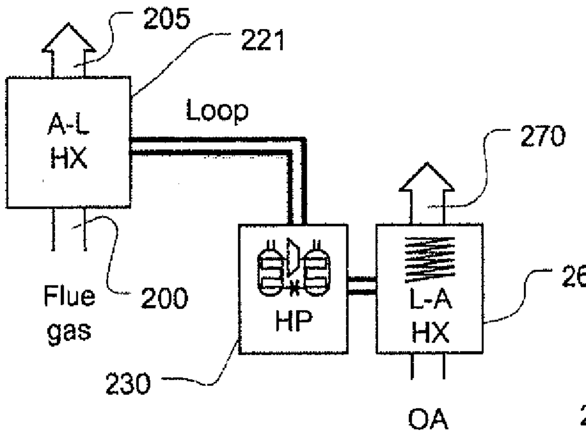

FIG 2e

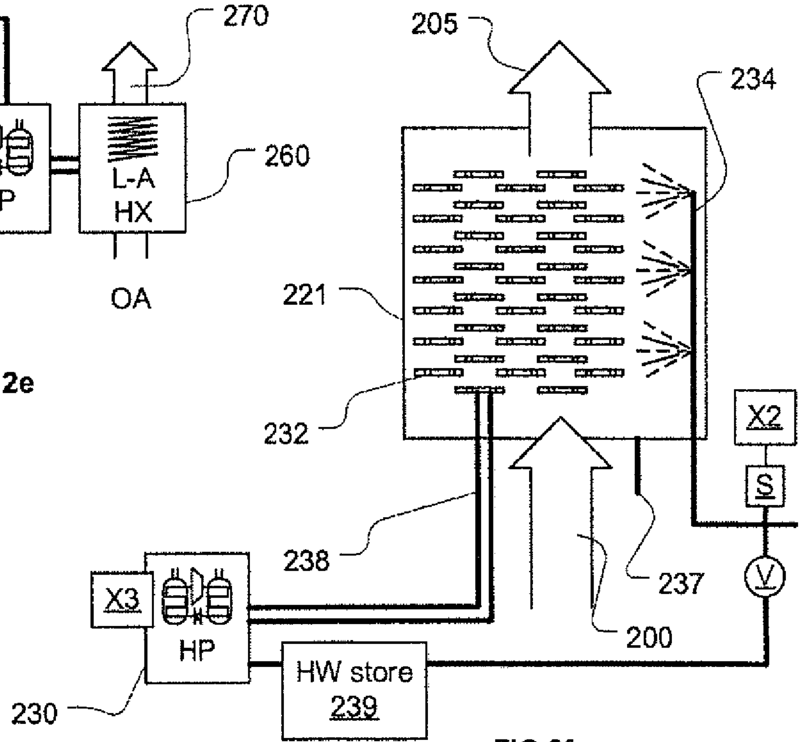

FIG 2f

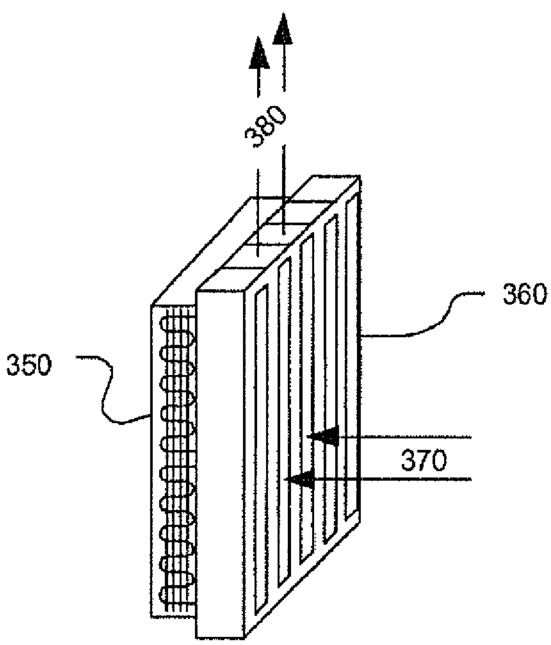

FIG 3a

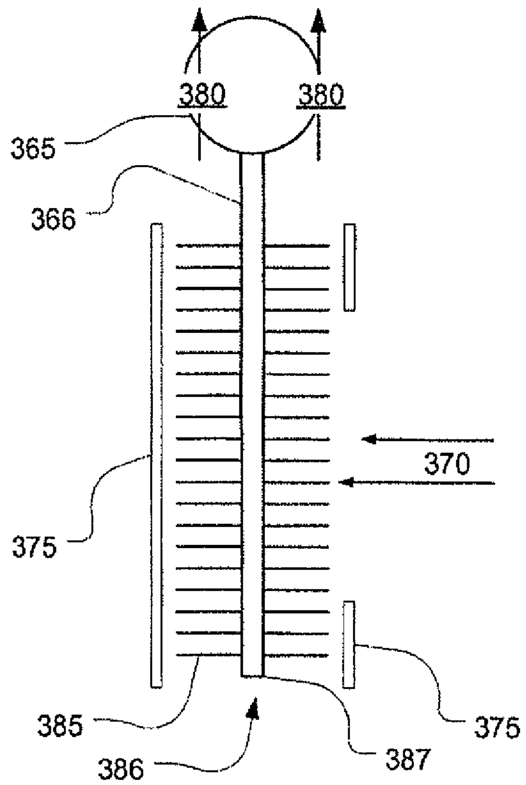

FIG 3c

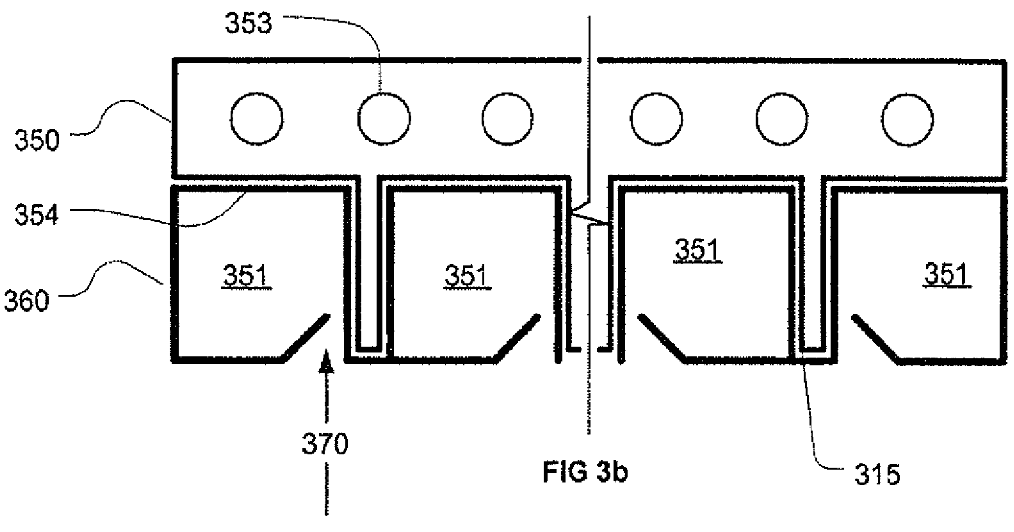

FIG 3b

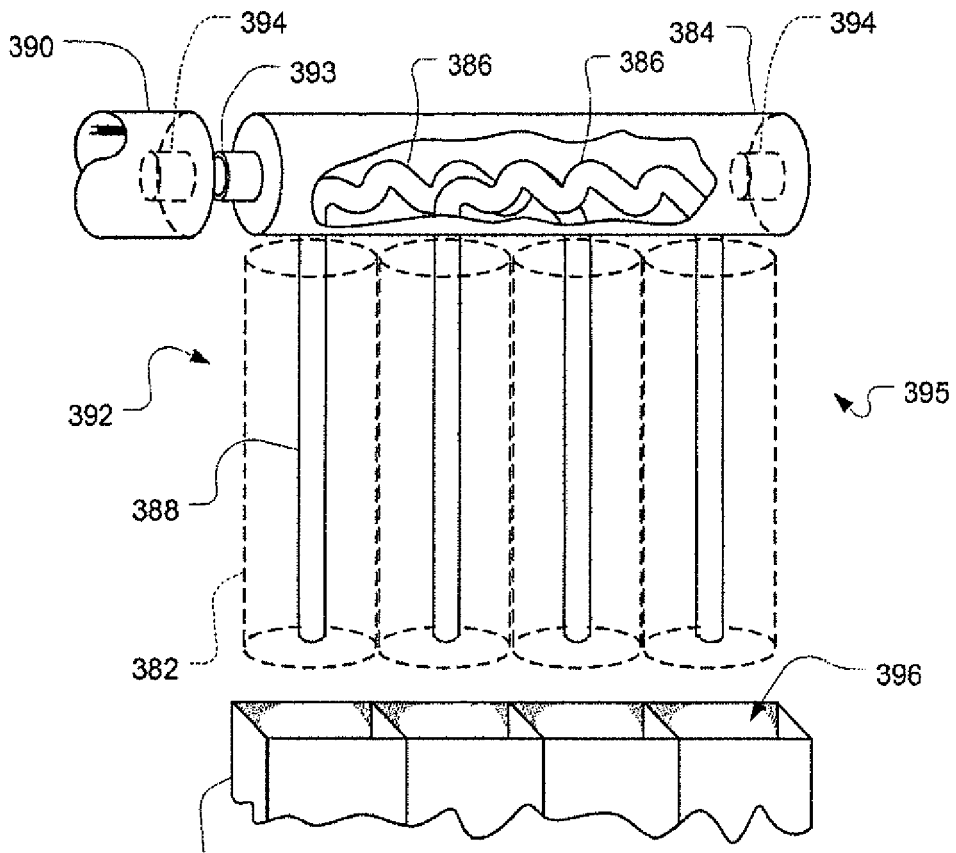

FIG 3d

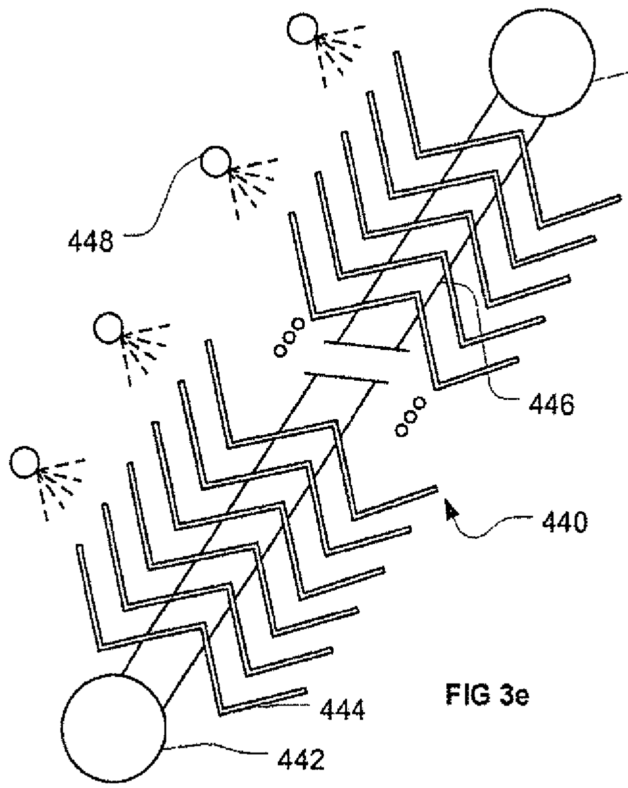

FIG 3e

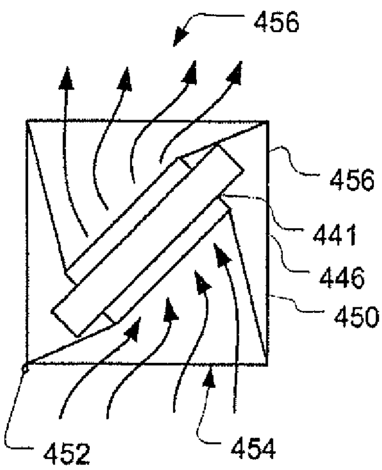

FIG 3f

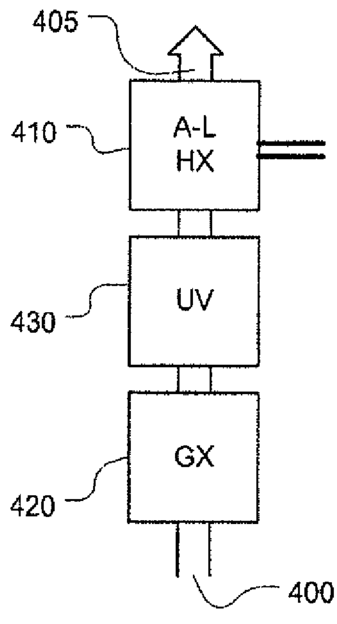

FIG 4a

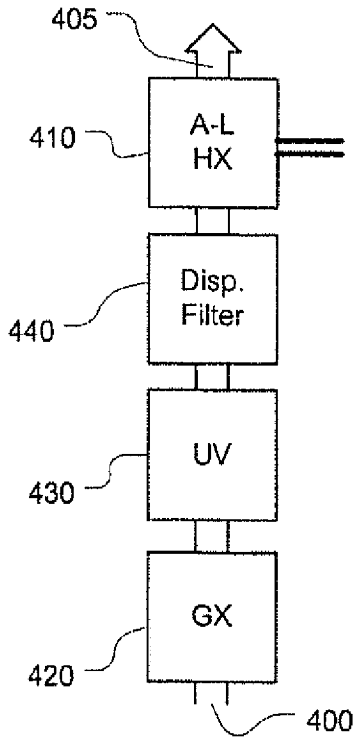

FIG 4b

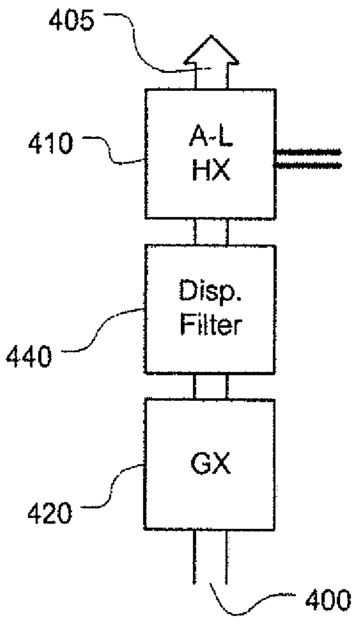

FIG 4c

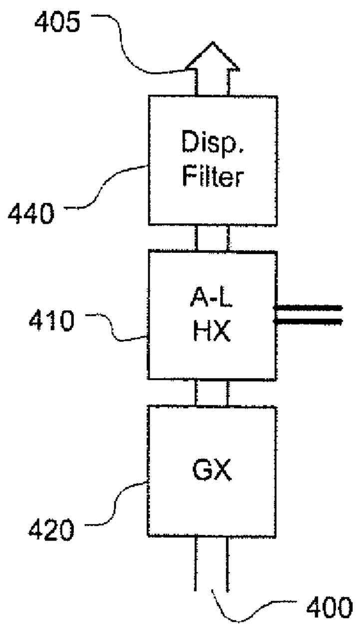

FIG 4d

REFERENCES CITED IN THE DESCRIPTION

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