United States Patent [19]

King

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[54] **VENTILATING SYSTEM WASHER CLEANING APPARATUS**

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[73] Assignee: **Ayr King Corporation,** Louisville, Ky.

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[52] **U.S. Cl.** ..... **55/122;** 55/126; 55/139; 55/242; 55/260; 55/DIG. 36; 98/115 K

[51] **Int. Cl.²** **B03C 3/01**

[58] **Field of Search** ..... 126/299 R, 299 A, 299 B, 126/299 C, 300, 301; 98/115 R, 115 K; 55/108, 110, 111, 118, 122, 126, DIG. 36, 220, 239, 257, 259, 260, 242, 481, 139; 261/126, 115, 116, 117, 118

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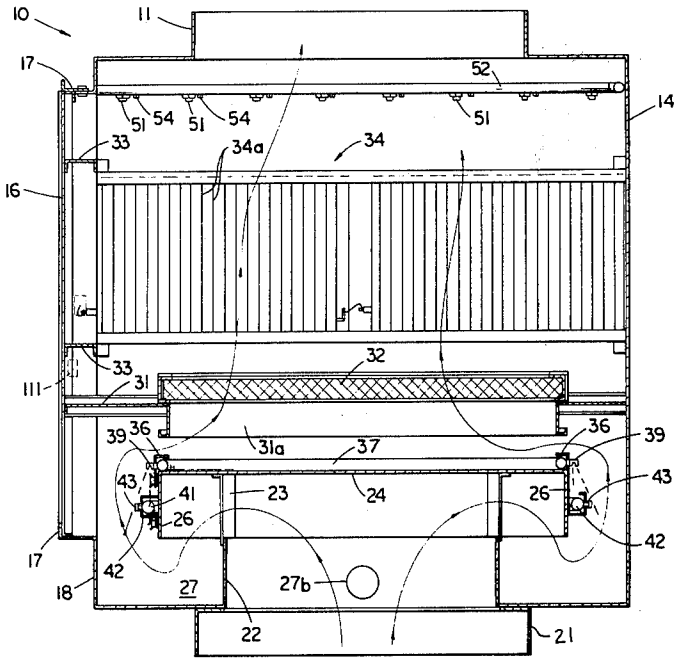
Primary Examiner—Bernard Nozick

Attorney, Agent, or Firm—Woodard, Weikart, Emhardt & Naughton

[57] **ABSTRACT**

An apparatus for clearing ventilating systems of grease vapors, odors, smoke and the like which comprises a housing having inlet and outlet passages and enclosing between these passages, sequentially in the direction of air flow, a centrifugal extractor thereby substantially reversing the airstream flow, a continuous cold water spray intersecting and directed counter to the airstream flow and a group of electrostatic precipitators. The combined action of the extractor, water spray and precipitators remove variously sized grease, vapor and smoke particles from the ventilating airstream.

2 Claims, 6 Drawing Figures



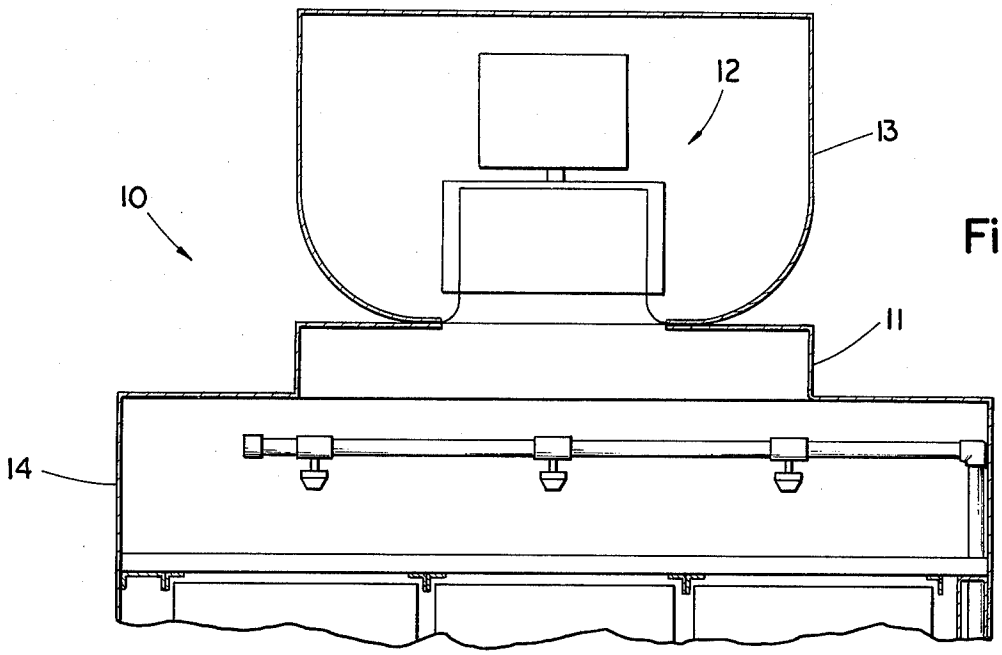

10
12
13
11
14

Fig. 1

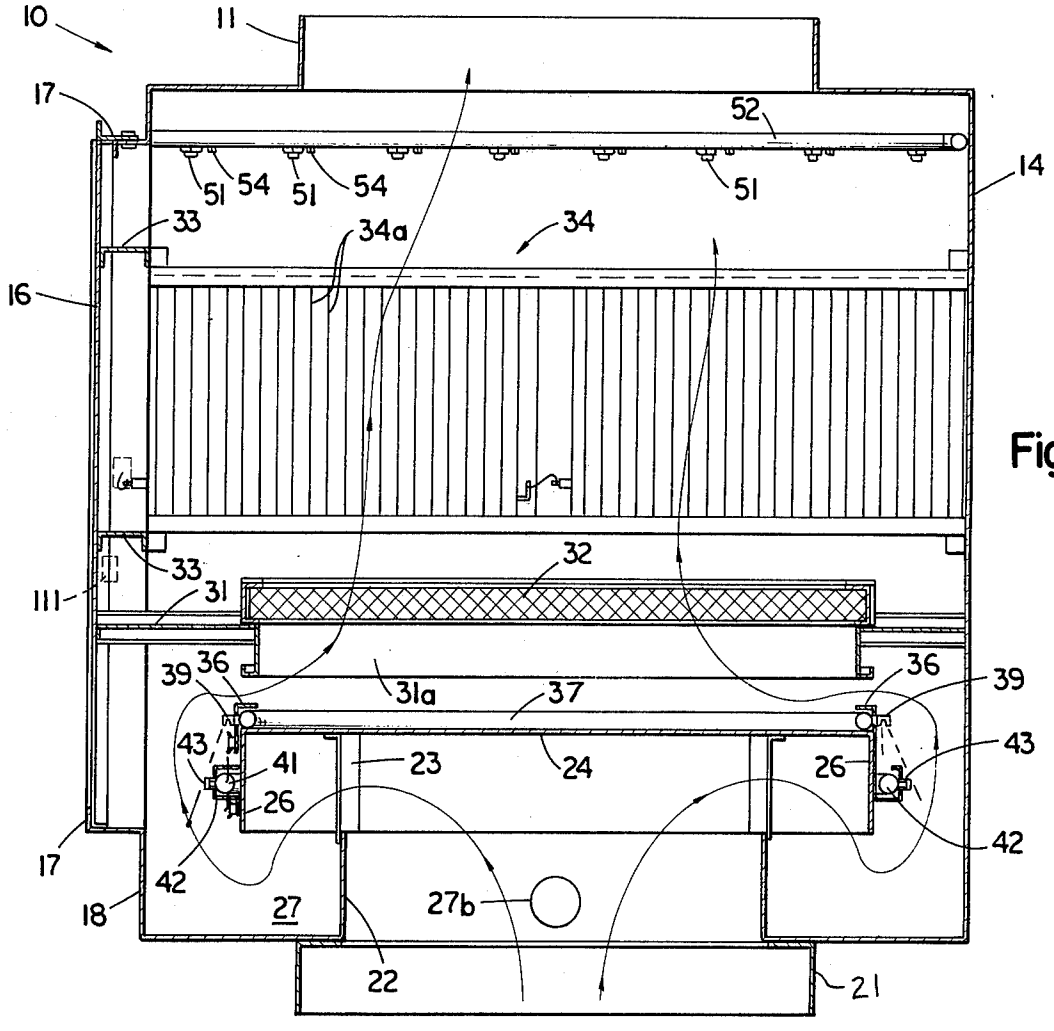

10
11
17
52
51
54
51
54
51
14
33
34a
34
16
33
32
111
31
39
36
31a
37
36
39
43
41
23
24
26
43
26
42
42
17
18
27
27b
22
21

Fig. 2

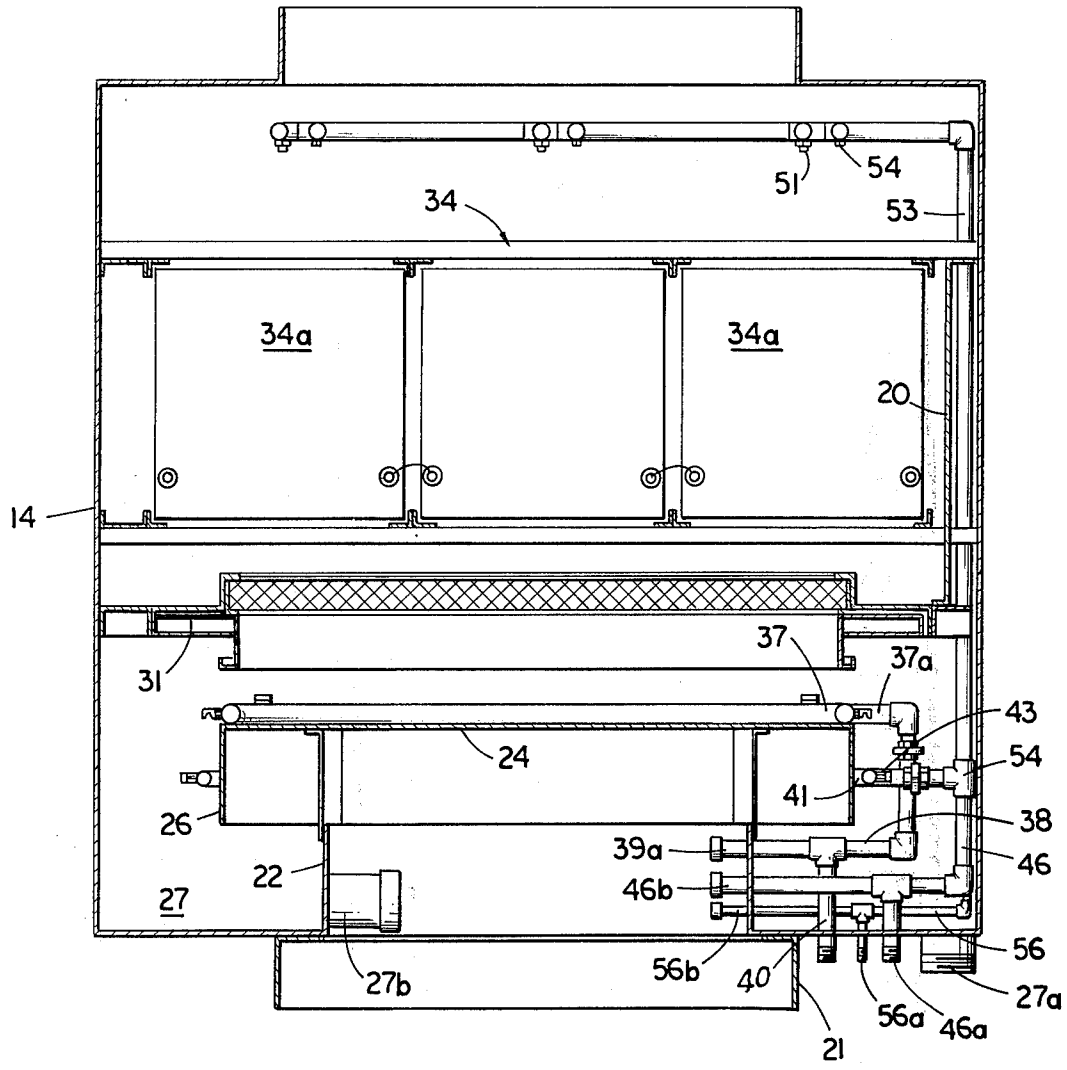

51
54
53
34
34a
34a
20
14
31
37
37a
43
54
24
41
38
26
39a
46
22
46b
27
56
56b
40
27b
27a
56a
46a
21

Fig.3

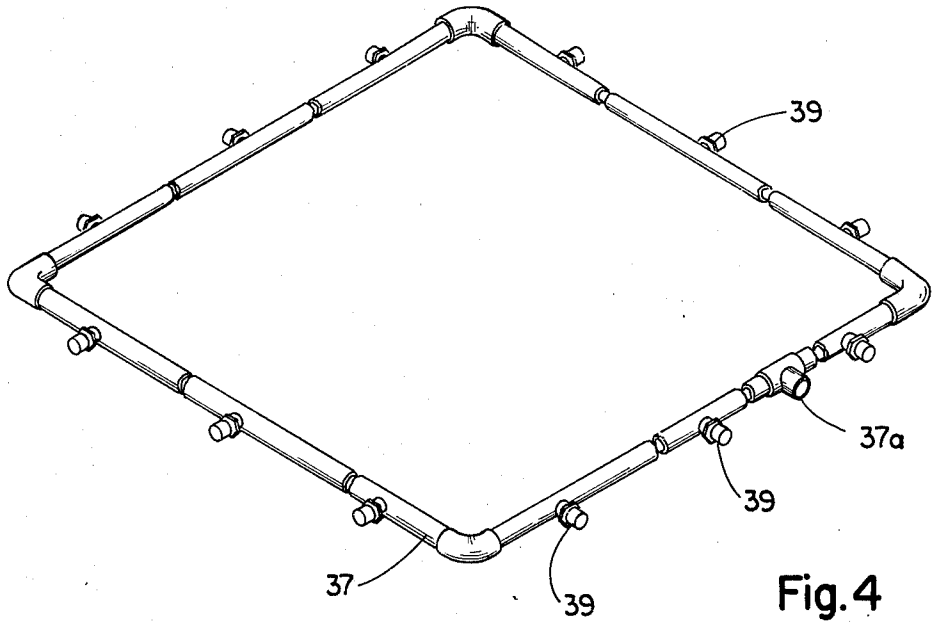


Fig. 4

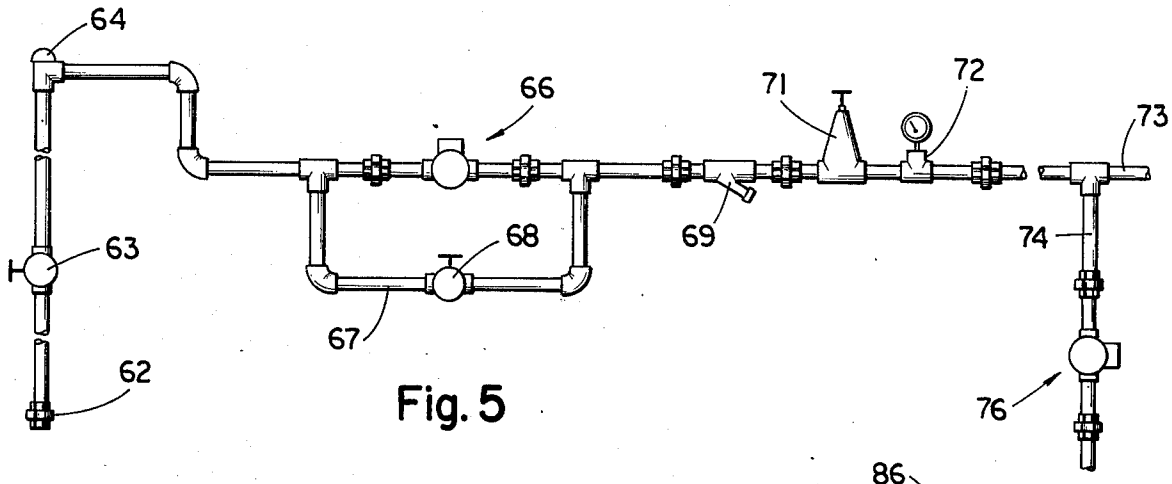


Fig. 5

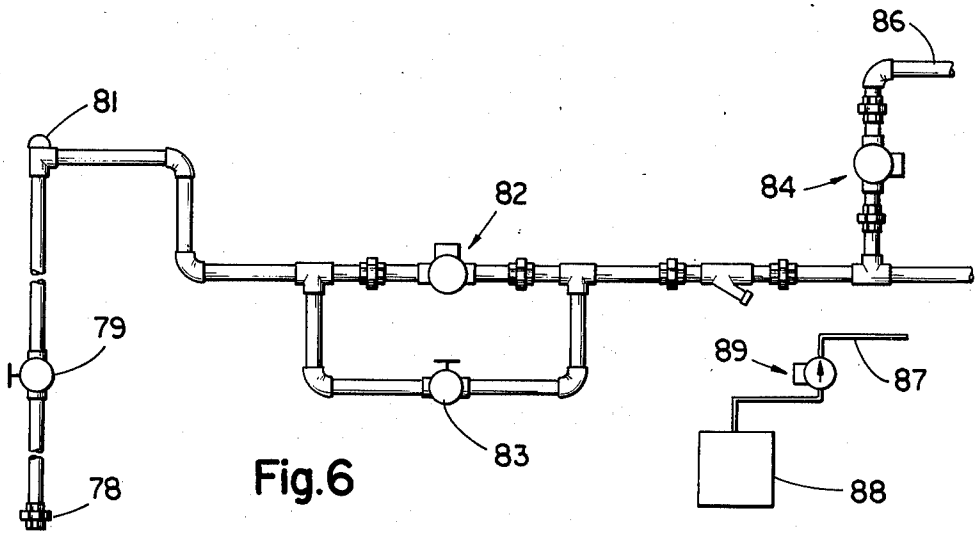


Fig. 6

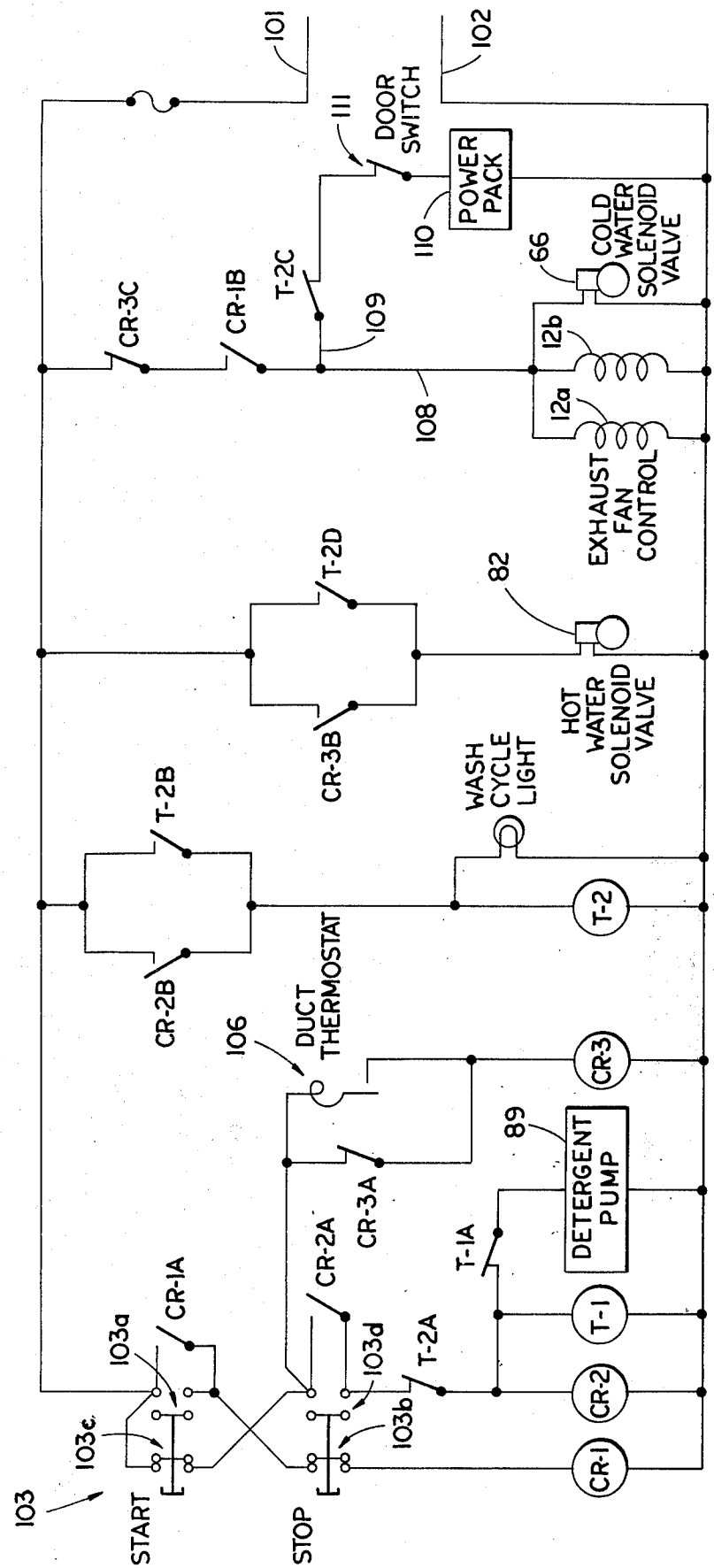

101
102
111
DOOR SWITCH
POWER PACK
110
66
COLD WATER SOLENOID VALVE
T-2C
109
CR-3C
CR-1B
12b
12a
108
EXHAUST FAN CONTROL
T-2D
82
HOT WATER SOLENOID VALVE
CR-3B
WASH CYCLE LIGHT
T-2B
T-2
CR-2B
106
DUCT THERMOSTAT
CR-3
89
DETERGENT PUMP
CR-3A
CR-2A
T-1A
CR-1A
103a
T-1
103d
T-2A
CR-2
103c
103b
CR-1
103
START
STOP

Fig. 7

VENTILATING SYSTEM WASHER CLEANING APPARATUS

BACKGROUND OF THE INVENTION

The ventilation of enclosures in which a smoke and grease laden atmosphere is generated (for example, commercial and institutional kitchens) is beset with problems. More generally, industrial installations also have difficulty with respect to, for example, removal of oil mist from the area adjacent to lathes and screw machines, removal of welding dust from in-plant welding shops, and removal of dust lint and vapors from various industrial processes. Difficulties in disposing of grease vapor, odors and smoke, time consuming clean-up and maintenance of the equipment and ventilating apparatus, the fire hazard resulting if such periodic clean-up is not rigorous are some of the difficulties involved. Air-pollution ordinances have foreclosed the possibility of meeting these difficulties by merely dumping the contaminated ventilating airstream to atmosphere exterior of the building or enclosure.

While use of electrostatic precipitators has, in the past, been attempted in dust, oil and grease vapor laden enclosure ventilation, the results have not been satisfactory because accumulation of grease on and adjacent the cells progressively inhibited their functioning. The appratus of the present invention succeeds in meeting the ventilation problem discussed above because it combines a cold water spray and a water-cooled centrifugal extractor with the use of the electrostatic precipitators. The centrifugal extractor and cold water curtain, directed generally counter to the flow of the ventilating airstream, serve to remove and wash away heavier grease vapors and the larger of the smoke particles. Since these are removed prior to entry of the airstream into the precipitator cell area, the cells can perform, without pregressive inhibition of their function, removal of the final smaller particles remaining in the airstream.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary, schematic, sectional side view of an apparatus embodying the present invention and showing a typical power driven fan used with the apparatus.

FIG. 2 is a side sectional view of apparatus embodying the present invention.

FIG. 3 is a futher sectional view similar to FIG. 2.

FIG. 4 is a perspective view of the array of cold water nozzles and their manifold.

FIG. 5 is a schematic view of the piping arrangement for the continuous cold water spray nozzle array shown in FIG. 4.

FIG. 6 is a schematic illustration of the piping arrangement for the wash-down nozzle array.

FIG. 7 is a schematic showing of the electrical circuit for the apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIG. 1 the apparatus of the present invention is shown generally at **10** and is formed by a tubular housing, the upper end of which is formed to provide an outlet collar **11** on which is mounted a motor driven fan **12** enclosed in a suitable housing **13.** The fan **12** and the housing protecting it may be of any suitable type drawing air through the housing **10** and discharging it in any suitable fashion either peripherally around the housing **13** or over the open upper end of the housing. It will be understood that the fan structure and the housing **13** form no part of the present invention but merely illustrate the environment in which the apparatus of the present invention, enclosed by the housing **14,** is utilized. The fan **12** merely serves to initiate the flow of ventilating air through the housing **14** which is shown in detail in FIGS. **2** and **3.**

Referring particularly to FIG. **2,** the housing **14** is shown as generally rectangular and tubular in configuration, one sidewall of the housing being formed by an access door **16.** The access door is removable by moving the door latch member **17** out of overlying relation to the upper edge of the access door and then sliding the access door upwardly out of itss peripheral retaining members **17** formed integrally with the housing sidewall indicated at **18.**

At its lower end the housing **14** carries an inlet collar **21** which is adapted to be installed on, for example, an existing roof-top duct exit, the apparatus and housing **14** thus being interposed between the roof-top duct exit and the conventional roof-top fan assembly which may be accommodated on the outlet collar **11.** The housing, adjacent the collar **21,** is provided with an inwardly turned flange **22** which thus forms an inlet passage for the airstram entering through the collar **21** as indicated by the air flow arrows in FIG. **2.** The upper margin of the collar **22** carries brackets **23** which support a baffle or plate **24** having a depending skirt **26** which extends toward the collar and to a point generally aligned with the upper margin of the inlet passage formed by the collar **22.** The inlet passage formed by collar **22** is smaller in cross section than the housing which extends outwardly to its sidewalls and thus forms a peripheral trough within the housing indicated at **27** as will be evident from the flow arrows of FIG. **2.** The direction of flow of the airstream is substantially reversed by the skirt **26** of the baffle **24** and the airstream moves toward the base of the trough **27** but is again directed upwardly, by the trough, toward the outelet at the top of the housing **14.**

Above the baffle **24,** the housing carries a support frame **31** which has a depending portion **31***a* forming an entry to the flat filter member **32** which is supported on the frame **31.** The filter **32** serves as a mist, or moisture droplet barrier, and removes droplets from the airstream which progresses upwardly through the filter.

Supported on appropriate mounting members **33** is an array of electrostatic precipitator cells indicated generally at **34.** These electrostatic precipitator cells are well known in the prior art and are formed by collector plates **34a** and include an ionizing section provided with a relatively high DC voltage. Any particles remaining in the airstream as it passes upwardly through the cells move through the ionizing section and are there given a positive charge. As these charged particles pass up into the collecting plate sections, they are attracted and held to the ground potential plates by a strong electrostatic field. As indicated by the arrows in FIG. **2** the airstream, after moving through the precipitator cells continues upwardly to exit through the outlet collar **11.**

As may be seen in FIGS. **2** and **3,** suitable brackets **36** carried on the exterior surface of the skirt **26** support a continuous, rectangular header pipe **37** which is shown in detail in FIG. **4.** A connecting tee **37***a* pro-

vides for supply of cold water to the manifold **37.** As may best be seen in FIG. **3,** the tee **37***a* is connected to a supply pipe **38** which has a branch **40** extending to the exterior of the housing and to the extending end of which a controlled, cold water supply pipe may be connected, the piping connections being shown in detail in FIG. **5** to be described subsequently. A capped alternate cold water inlet connection **39***a* is provided for use as an alternate cold water inlet connection where the piping must be brought to the assembly through the duct work on which the assembly is mounted. It will be understood that when the alternate supply connection **39a** is utilized, the supply connection **40** would be capped. Spaced around the length of the header **37** are continuous water wash nozzles **39** which are of a conventional type and provide a spray pattern generally in the form illustrated in broken lines in FIG. **2.** It will be noted that this cold water spray issuing from the nozzles **39** is directed generally counter to the flow of ventilating air as it moves from the trough **27.** Supported on the skirt **26** somewhat below the nozzles **39** is generally rectangular configurated wash-down water manifold **41.** Brackets **42** support the manifold and spaced along its length are outwardly directed wash-down nozzles **43** which are of conventional construction but which differ in spray pattern from the nozzles **39** in that they direct peripherally outwardly a conical water spray of approximately **120** degrees. This wash-down water, supplied at intervals as will subsequently be described, moves down the inner surface of the housing sidewalls and into the trough **27** from whence it, together with the water resulting from the spray issuing from the nozzles **39,** drains from the trough **27** through the drain connection **27***a* (FIG. **3**). The grease and particle laden drain water may be passed through a suitable grease removal unit (not shown) before discharge into the conventional drainage system. As may best be seen in FIG. **2,** the wash-down water to the header **41** is supplied by a pipe **46** and a portion **46***a* of this pipe extends to the exterior of the housing and permits connection of a controlled supply of hot water to be described in detail with reference to FIG. **6.** The capped extension **46***b* of the pipe permits an alternate supply connection through the duct work.

As may best be seen in FIGS. **2** and **3** an array of hot water, wash-down nozzles **51** is supported in overlying relation to the precipitator cells, the nozzles being supplied by the header **52** which is connected to the downwardly extending pipe **53** (FIG. **2**) which joins the pipe **46** at the tee-connection **54.** Adjacent the nozzles **51** are nozzles **54,** adapted for dispensing a detergent solution into the area above the precipitator cells for bathing the cells in the detergent solution at controlled intervals. Nozzles **54** are supplied by a separate header pipe adjacent the header pipe supplying the nozzles **51** and this detergent supply header is connected to the pipe **56** (FIG. **3**) which has a portion **56***a* extending to the exterior of the housing and which is adapted to be supplied with a detergent solution. An extending portion **56***b*, shown capped in FIG. **3,** provides an alternate connection for supplying detergent to the pipe **56** and the nozzles **54.** An alternate connection for the trough **27,** to be used where the drain piping must be brought through the duct work on which the apparatus is installed, is indicated at **27***b* in FIG. **3,** this drain being capped when the drain connection **27***a* is utilized.

Referring to FIG. **5,** the control connections for the continuous spray nozzles **39** will now be described. The union **62** is connected to the cold water supply source and a manual stop valve **63,** together with a vacuum breaker **64** are provided. The solenoid valve **66** controls the flow of cold water (a by-pass line **67** controlled by a manual valve **68** is also provided) the manual valve **68** normally being closed during operation. The cold water supply line includes a line strainer **69,** a pressure regulator **71** and a pressure gage **72.** The downstream end **73** of the cold water line is connected to the cold water nozzle line **39** (FIG. **3**) which supplies water through the pipe **38** to the nozzles **37***a*. A branch line **74** to the drain may be suppled and is controlled by the normally open solenoid valve **76.** The line **74** and the solenoid valve **76,** when present in the system, provide a means for automatically bleeding the supply and nozzle lines when the system is shut-off, thus preventing these lines from freezing in climates where this precaution is necessary.

Referring to FIG. **6,** the piping arrangement for supplying hot water to the nozzles **43** and **51,** and detergent solution to the nozzles **54,** will now be described. The piping system for supplying hot water to the line **77** which is connected to the line **46***a* (FIG. **3**) includes a union **78** which is connected to a source of hot water supply, a stop valve **79,** a vacuum breaker **81** and a normally closed solenoid valve **82.** A by-pass including the manual stop valve **83** is provided around the solenoid valve, the valve **83** being closed during normal operation of the apparatus. A normally open solenoid valve **84** in the line **86** to the drain provides an arrangement for bleeding the line where temperatures require precaution against freezing. The detergent supply line **87** is connected to the line **56***a* (FIG. **3**) and extends to a detergent solution container **88,** flow from which through the line **87** is established by the electrically energized detergent pump **89.** The control system for the apparatus is shown schematically in FIG. **7.** It includes the power line members **101** and **102** and a start-stop, push-button switch **103** which has normally open stop contacts **103***a* and normally closed stop contacts **103***b* connected in series with the control relay CR-1 Series connected contacts **103***c* and **103***d* are connected in series with a pair of contacts identified at T-2A and to the control relay identified at CR-2. Contacts T-2A are controlled by the timer motor T-2. Once timer motor T-2 has been energized, the contacts T-2A are not reclosed until a time delay subsequent to de-energization of the timer T-2. The timer T-1 is energized with relay control CR-2 and the detergent pump **89** is connected to this circuit through the normally closed timer actuated switch T-1A. The contacts T-1A are opened by the timer T-1 after a short time period of the order of **15** seconds so that detergent solution is supplied to the nozzles **54** only for this short period during the wash-down cycle. The start-stop switch **103** is provided with holding contacts CR-1A and CR-2A which are closed by the energization of the relay coils CR-1 and CR-2, respectively. Connected between the upper one of the contacts CR-2A and the supply line **102** is a control relay identified as CR-3 which has in series with it a duct temperature responsive member or thermostat indicated at **106.** Normally open holding contacts CR-3A, closed by energization of the relay CR-3, hold the relay energized once the thermostat **106** has been closed indicating an abnormally high temperature in

the airstream. The thermostat **106** is not shown in FIGS. **2** and **3,** however, it will be understood that it functions as a reverse-acting high temperature limit control and is appropriately located in the duct work through which the ventilating airstream passes as it moves to the apparatus of the present invention. The timer T-**2** is connected across the lines **101** and **102** through the parallel connected control relay switch identified at CR-**2B** and timer controlled switch T-**2B,** energization of the control relay CR-**2** closing the switch CR-**2B** and the switch T-**2B** being closed by the timer T-**2.** A wash cycle indicator light may be provided in parallel with the timer T-**2.**

The hot water solenoid valve **82,** mentioned previously, is connected across the power lines **101** and **102** by means of the parallel connected switches CR-**3B** and T-**2D.** The switch CR-**3B** is closed upon energization of the relay CR-**3** and the switch T-**2D** is closed by the timer switch T-**2** after a delay period of approximately **5** minutes subsequent to energization of the timer T-**2.**

A normally closed relay switch identified as CR-**3C,** and opened upon energization of the control relay CR-**3,** is connected in series with a normally open pair of contacts identified as CR-**1B,** these contacts being closed upon energization of control relay CR-**1.** These series connected relay switches have connected to them a circuit branch identified at **108** which connects to the parallel connected members **12***a*, 12*b* and cold water solenoid valve **66.** The exhaust fan control coil is identified by **12***a*, and, it will be understood, that energization of the member **12***a* causes closing or completion of the electrical power circuit to the driving motor of the ventilating fan **12** (FIG. **3**). The control member **12***b* represents the energizing coil for a control switch which energizes the electrical motor driving a make-up air fan which, in some applications, is located in the duct leading to the enclosure (kitchen) from the outside. The makeup air fan is not shown (other than its controller **12***b* of FIG. **7**) since its presence is optional and is not included in all installations. The solenoid valve **66** is, of course, the cold water solenoid valve shown in FIG. **5,** and controls the flow of cold water to the nozzles **39** (FIG. **2**).

Connected in parallel to the circuit branch **108** is a wire **109** which serves to connect the power pack **110** to the power input. In series with the power pack **110** are normally closed timer switch T-**2C** and the normally closed door switch **111.** The door switch **111** is shown in FIG. **2** and is mechanically closed by the presence of the access door **15.** When the access door **16** is opened or removed from the bracket **17,** the door switch **111** is opened, the switch thus functioning as a safety switch permitting energization of the power pack **110** only when the door **16** is in place. The power pack **110** is primarily a step-up transformer and a rectifier which supply the elevated, DC voltage necessary to provide the ionizing charge to the precipitator plates **34**a. The switch T-**2C** is opened upon starting of the wash cycle, that is, when the timer T-**2** is energized and is returned to closed position only after a time interval of the order of **30** minutes has elapsed subsequent to the termination of the wash cycle to provide against the precipitator cells being energized before they have dryed subsequent to the wash cycle.

In operation, to start the system, the start button of the switch **103** is depressed therby energizing control relay CR-**1.** This causes energization, through the switch CR-**1B** and wire **108,** of the exhaust fan **12,** the make-up air fan **12***b*, if such is used, and energizes the cold water solenoid valve **66** providing a cold water spray from the nozzles **39** (FIG. **2**). Assuming the access door **16** is in place, the power pack **110** and the precipitator cells are also energized through the relay contacts CR-**1B.** Operation may now continue as desired and when the apparatus is to be de-energized, the stop button of the switch **103** is depressed. De-energization of control relay CR-**1,** through opening of the relay contacts CR-**1B** thereupon de-energizes the fan controls **12***a* and **12***b* and closes the cold water solenoid valve **66** and de-energizes the power pack **110.** Depression of the stop-button of the switch **103** causes control relay CR-**2** to be energized through the contacts **103***c* and contacts **103***b* of the switch **103.** Energization of relay CR-**2** closes relay contacts CR-**2B** and energizes timer T-**2.** Timer T-**1** is also energized as is the detergent solution pump **89** so that detergent solution is sprayed from the nozzles **54** (FIG. **2**) for a timer interval until time T-**1** opens the contacts T-**1A,** the time interval being of the order of **15** seconds. Because the timer T-**2** closes the contacts T-**2D** only after a time delay, subsequent to its energization, of approximately 5 minutes, the detergent solution sprayed from the nozzles **54** onto the precipitator cells is permitted to soak until the 5 minute delay interval timed by the timer T-**2** has been completed and switch T-**2D** is closed, thereby opening the hot water solenoid valve **82** which supplies rinsing hot water spray to the nozzles **51** and the nozzles **43** (FIG. **2**). This rinse or wash-down cycle is completed at the end of the predetermined time interval by opening of the timer contacts T-**2D** by the timer T-**2.** The timer motor T-**2** retains the timer contacts T-**2C** open for the 30 to 40 minute interval necessary to assure that the precipitator cells have dryed. After this time period passes, the timer T-**2** opens the contacts T-**2A,** de-energizing the timer and the wash cycle light. Operation of the apparatus may then be restarted by again depressing the start button of the switch **103.** It should also be noted that operation of the exhaust fan **12** (energized by controller **12***a*) and the continuous water wash controlled by solenoid valve **66,** and issuing from nozzles **39,** can be reinstituted without waiting for the lapse of the time interval necessary for reclosure of timer switch T-**2C** and reenergization electrostatic precipitator power pack **110.** Depressing the start button of switch **103** immediately after release of the stop button deenergizes relay CR-**3,** closing switch Cr-**3C,** and energizes relay CR-**1,** closing switch CR-**1B.** The exhaust fan **12** and the cold water spray (controlled by solenoid valve **66**) are thus restarted immediately. This mode of operation is utilized where the process being ventilated cannot be shut down for any extended period of time. As the circuit of FIG. **7** indicates, the system can be stopped without automatically going into the wash-down cycle by depression of both the start and stop buttons of the switch **103** simultaneously.

When both buttons are depressed simultaneously control relay CR-**2** is not energized and timer T-**2** is not started and the wash-down cycle does not occur.

It should be noted that a safety feature is provided in that the duct thermostat **106** overrides all other controls in the circuit to start water flow from the wash-down nozzles **43** and **51** upon the existance of an abnormally high temperature in the air flow duct. With

the system in operation and the switch **103** in released or quiescent condition, closure of duct thermostat **106** energizes control relay CR-3, which closes relay switch CR-3B energizing solenoid valve **82** and causing wash-down nozzles to spray water until the start button of switch **103** is manually depressed. If thermostat **106** remains closed, indicating the abnormal duct temperature persists, the flow of wash-down water will immediately start again when the start button is released, and the system cannot be reset by the start button until after the duct thermostat **106** has opened its contacts.

Referring again to FIG. **3**, it will be noted that one side of the housing **14** is provided with a drain panel **20** to permit water from the precipitator cell area to drain back to the drainage area provided by drain connection **27***a* when the apparatus is installed horizontally, rather than vertically as shown in FIGS. **2** and **3**.

From the foregoing it will be evident that the apparatus of the present invention combines three elements to clean grease vapors, odors and smoke from ventilating systems. These combined elements are the water cooled centrifugal extractor formed by the trough **27** and baffle skirt **26** which causes a reversal in the airstream flow depositing the heavier particles entrained in the airstream at the base of the trough **27**. The continuous water washing of the airstream, flowing counter to the water spray, provided by the nozzles **39** tends to remove remaining grease vapors and larger greasy smoke particles from the airstream. The electrostatic precipitator component takes out the remaining small particles in the airstream. Since the larger particles are eliminated from the airstream before it reaches the precipitator cells, these operate with maximum efficiency.

As pointed out above, to facilitate cleaning and maintenance of the apparatus, a wash-down program is incorporated in the apparatus to automatically wash the electrostatic cells and the spray chamber or trough with hot water and detergent when the unit is shut-down. The baffle **24** with its depending skirt **26**, forming a part of the centrifugal extractor, can be removed for periodic complete cleaning and access to the nozzles. Access to the filter **32** and the precipitator cells can be obtained, as previously mentioned, through the access door. While the unit has been shown installed vertically on a roof-top for example, it will be understood that it might also be installed in horizontal position with the plate **20** lowermost.

I claim:

1. Apparatus for clearing grease vapors, odors, smoke and the like from enclosure ventilating systems having a power induced ventilating airstream discharged through an outlet mouth exterior of the enclosure, said apparatus comprising a generally tubular housing having one end providing an inlet passage and adapted to overlie and register with the outlet mouth of the ventilating system, the opposite end of said housing providing an outlet passage through which the cleansed ventilating airstream exits, said inlet and outlet passages being substantially in axial alignment, said housing having an inwardly turned flange at said inlet end completely encircling said inlet passage in the housing, said inlet passage being substantially smaller in cross section than the housing interior so that the housing sidewall and flange form a trough surrounding said inlet passage, a baffle plate overlying but spaced from said inwardly turned flange and having a peripheral skirt extending toward said trough whereby the direction of flow of said airstream is reversed and then redirected again toward the housing outlet as it flows around said skirt and out of said trough, electrostatic precipitator cells supported within said housing and disposed in said airstream downstream of said trough, and an array of nozzles supported on the downstream side of said baffle plate, said nozzles being positioned in spaced relation around the margin of the baffle plate and protruding slightly beyond said plate margin to deliver an axially directed spray of cold water in the annular space between the peripheral wall of the housing and said baffle skirt which intersects and flows substantially counter to the airstream as it flows between said skirt and said housing peripheral wall and prior to its movement past said precipitator cells.

2. Apparatus as claimed in claim **1** in which a further array of nozzles (**43**) encircles said baffle plate and is supported on said peripheral skirt of the baffle plate, said further nozzle array being disposed closer to the base of said trough than said first mentioned array of nozzles and adapted to deliver wash-down water to said trough.

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