

[54] **EXTENSIBLE INCINERATOR GAS
SCRUBBER SYSTEM WITH STANDARD
DUCTWORK**

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1970, abandoned.

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210/250, 261/DIG. 54

[51] **Int. Cl.**..... **B01d 47/00**

[58] **Field of Search** 210/250; 55/358, 227, 228,
55/229, 314; 261/DIG. 54; 248/157

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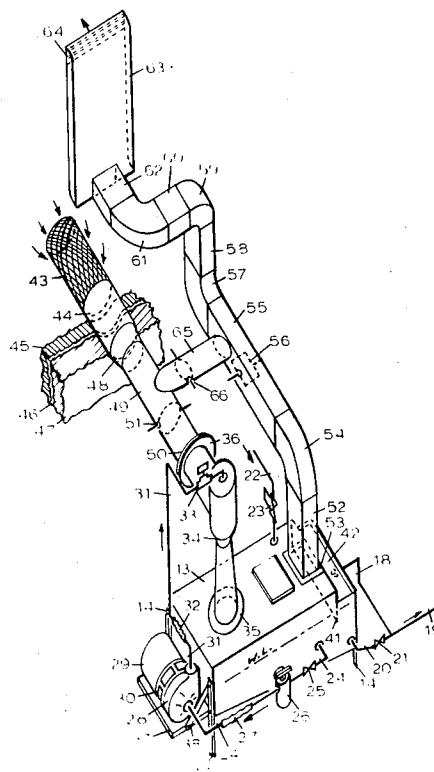
[57] **ABSTRACT**

This invention relates to the abatement of air pollution resulting from the discharge of combustion products from refuse incinerators.

The invention includes but is not limited to the apparatus of both recirculation-type tank-mounted ejector-venturi gas scrubber systems actuated by pressurized scrubbing liquid recirculated by an integral system pump, and drain-type tank-mounted ejector-venturi gas scrubber systems actuated by pressurized water supplied from a municipal water system or other outside source.

Height-adjustable gas washer units provide an extensible foundation for a standard system of inlet, bypass and discharge ductwork wherein the furnace intake of the scrubber system may be easily installed in a sheltered position adjacent the refractory furnace ceiling of apartment house incinerators having different designs and furnace heights. This extensible arrangement eliminates the need and expense for individual custom-type fit-up and shop fabrication of scrubber system ductwork as commonly practiced by installers.

7 Claims, 16 Drawing Figures



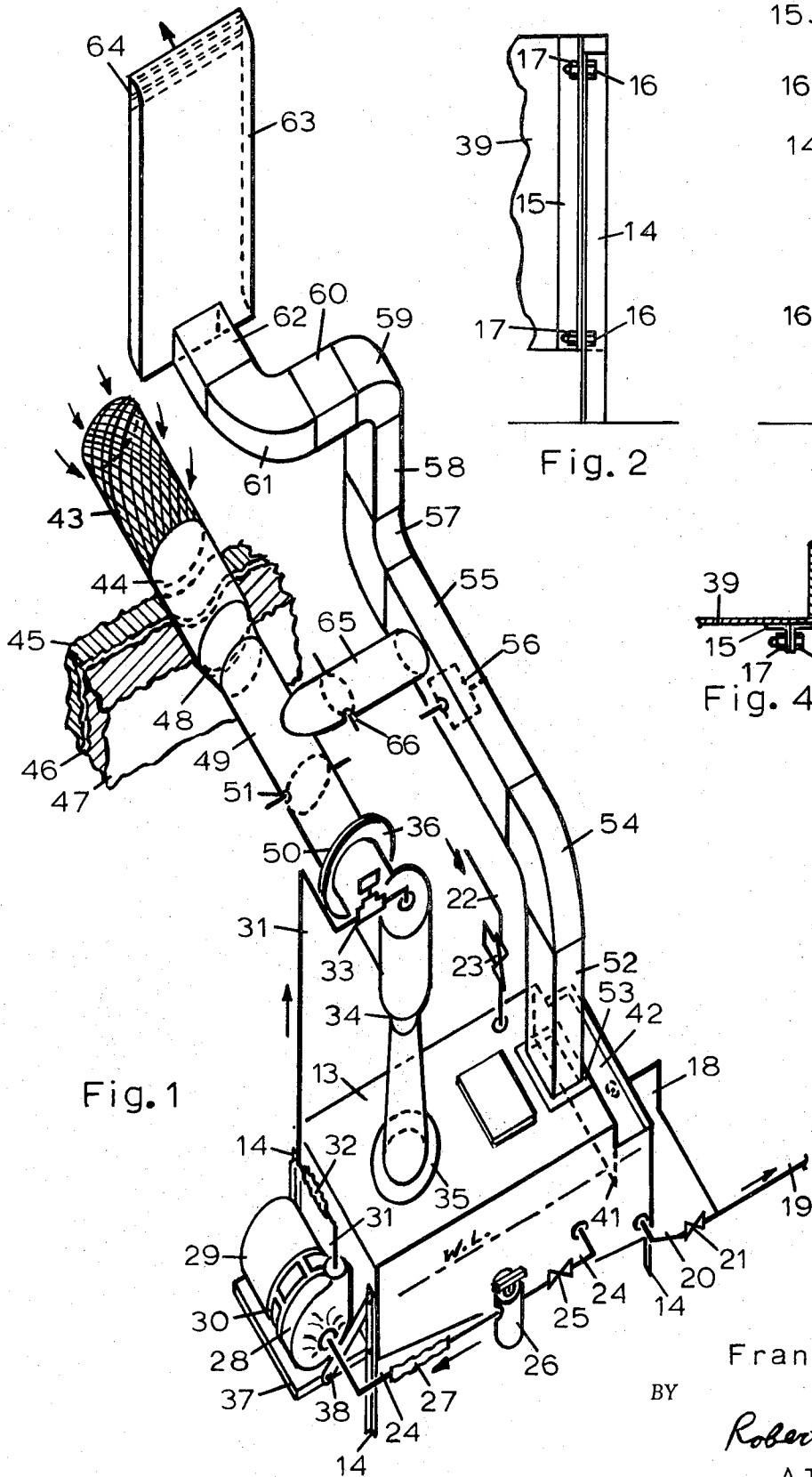


Fig. 1

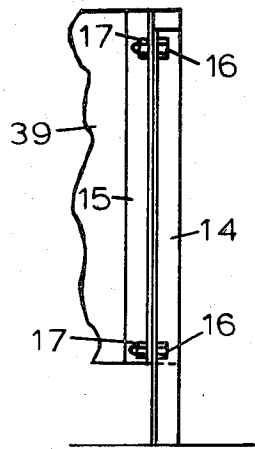


Fig. 2

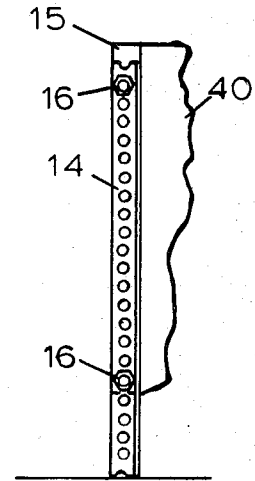


Fig. 3

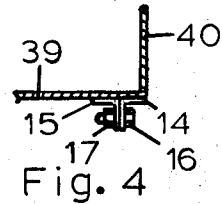
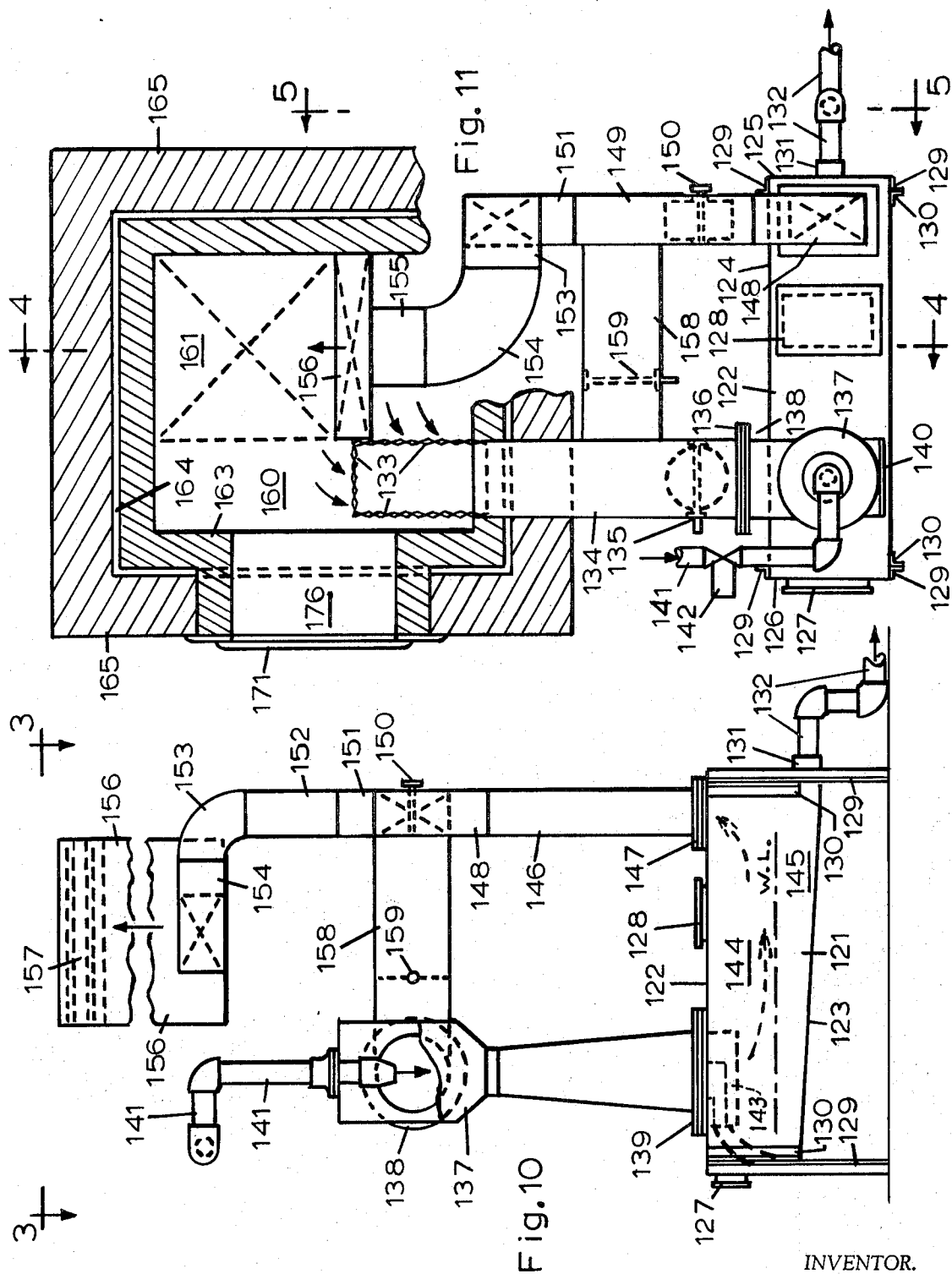


Fig. 4

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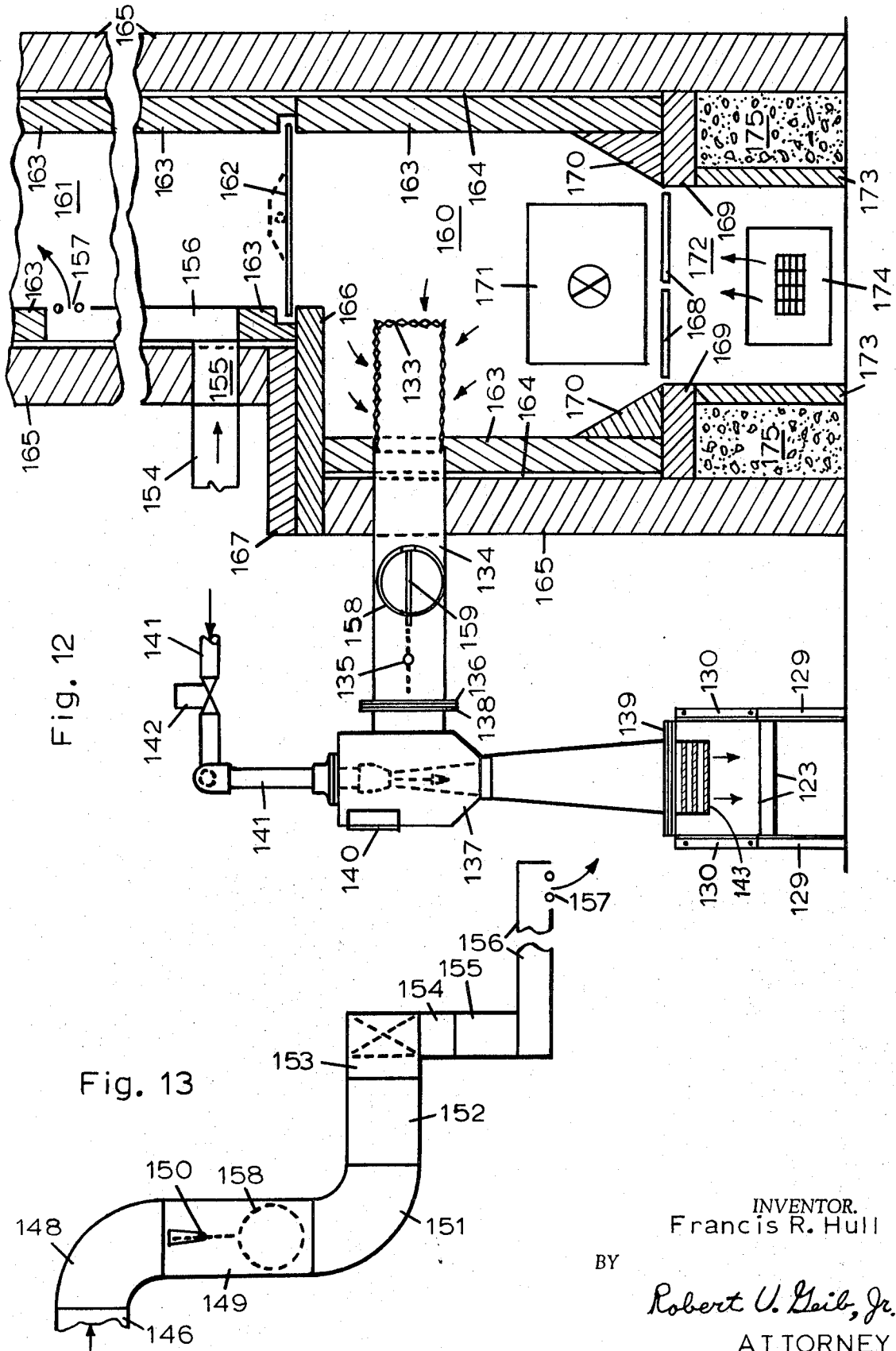
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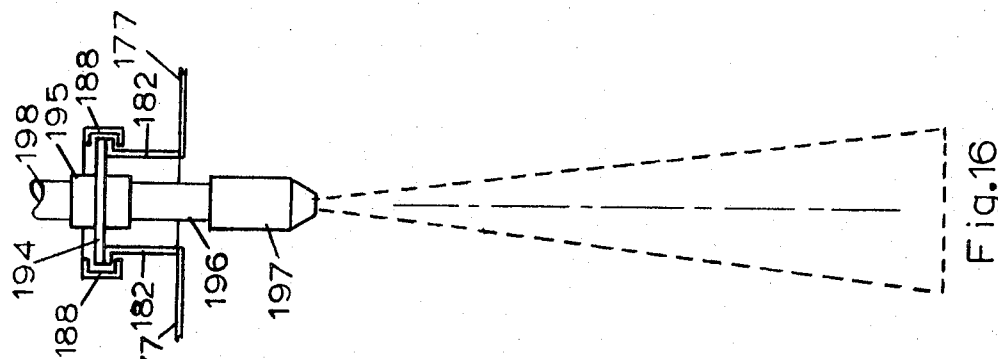
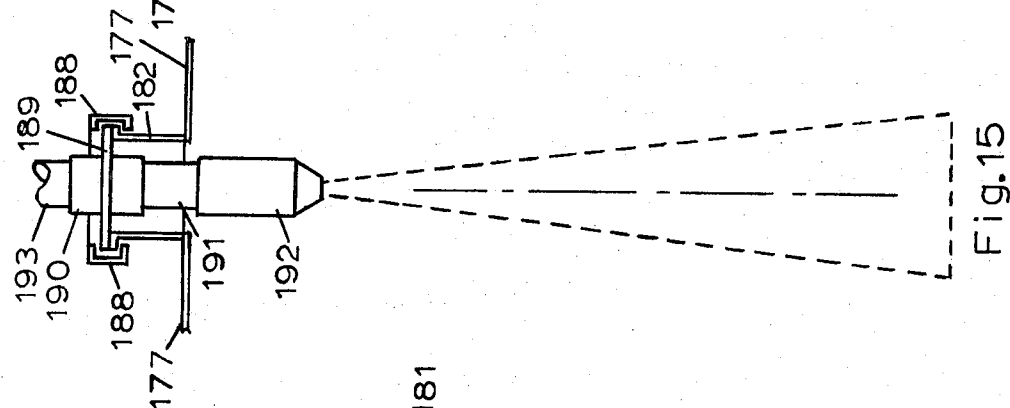
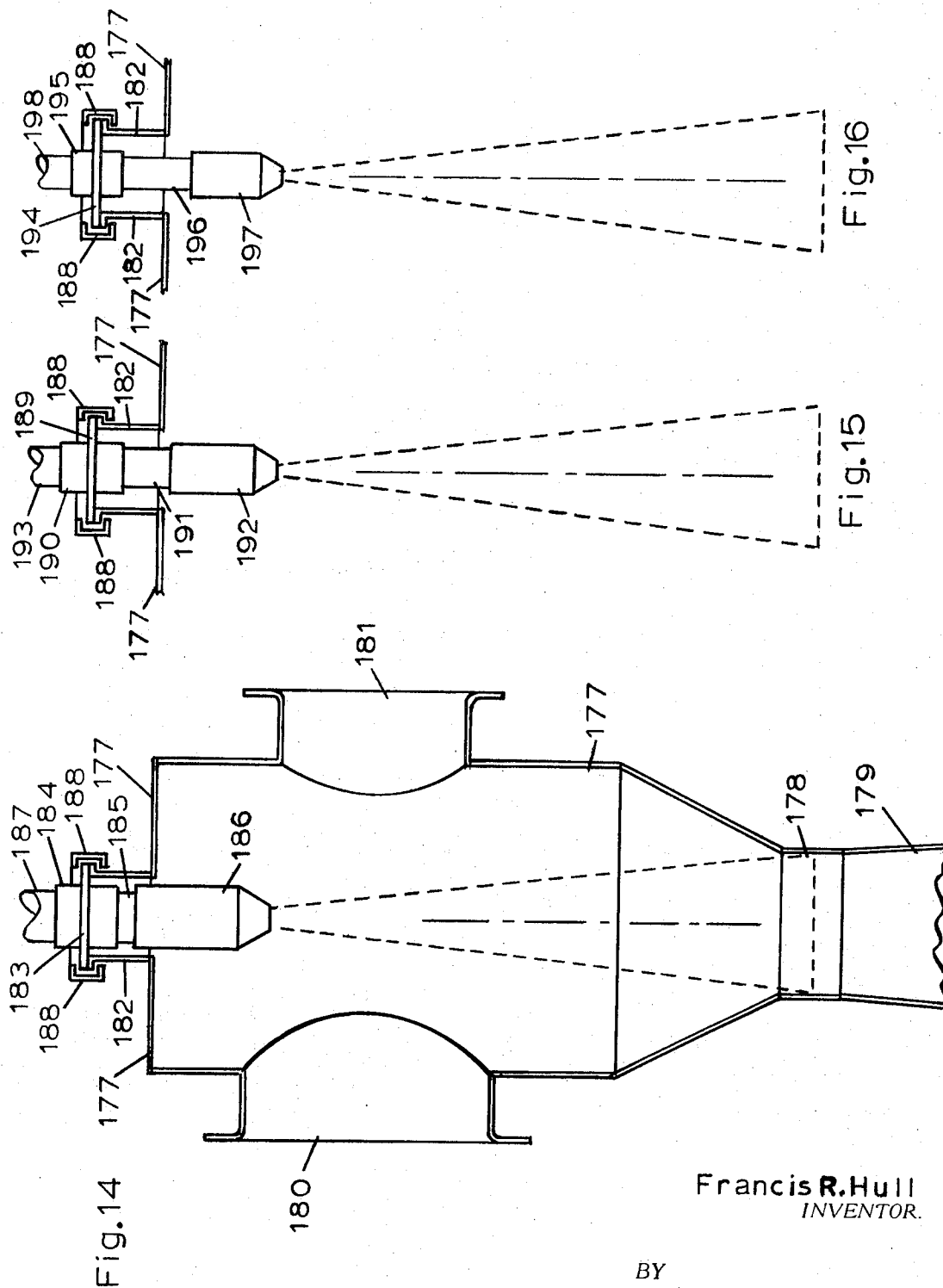
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EXTENSIBLE INCINERATOR GAS SCRUBBER SYSTEM WITH STANDARD DUCTWORK

The present invention is a continuation-in-part of my presently pending application Ser. No. 45,044 entitled "Extensible Incinerator Gas Scrubber Systems With Standard Ductwork" and filed June 10, 1970 now abandoned.

Widespread urban adoption of automatic and semi-automatic incinerator gas washer systems for the abatement of air pollution has been seriously hampered by cost considerations. Incinerator gas scrubber units, together with their inlet, bypass and discharge duct branches are normally made of stainless steel or other corrosion-resistant material to retard corrosive attack caused by the effects of combustion process by-products. A standard gas washer unit is normally produced by the manufacturer in different sizes for various capacity ranges. These standard gas washer units of fixed size are then installed to limit combustion products emissions from non-standard masonry incinerators which have different designs, geometry and furnace heights. These non-standard characteristics of existing incinerators as combined with the fixed configuration of a common standard gas washer unit forces the installer to individually custom-fit and shop fabricate the scrubber system ductwork branches of each incinerator installation.

It is among the objects of the present invention to provide a wet scrubber system with extensible supports and integral standard pre-fabricated inlet and discharge ductwork which may be readily installed into masonry penetrations at common inlet and discharge duct locations of non-standard incinerator systems.

Another object is to provide an extensible scrubber unit configuration with integral standard pre-fabricated inlet ductwork whose furnace intake may easily be elevated to a sheltered position adjacent the refractory furnace ceiling of non-standard incinerators having different furnace ceiling heights.

An additional object is to provide a wet scrubber system having a standard prefabricated discharge duct branch which may be installed into the incinerator smoke flue masonry adjacent the incinerator room ceiling with close installation clearances.

A further object is to provide a standard wet scrubber system configuration of simple economy and functional efficiency which is adapted to operation by automatic or semi-automatic control devices common to the emission control arts.

Another object is to provide an ejector-venturi gas scrubber unit of standard manufacture whose gas handling capacity may be easily and simply varied by the installation of alternate motive-nozzle assemblies.

As used herein:

the term "wet scrubber or wet scrubber system" shall relate to gas washer apparatus which removes particulate contaminants and condensable gas fractions from a contaminated gas stream by any method involving interaction between droplets of a scrubbing liquid and the contaminated gas stream in a process which tends to saturate the cleaned gas stream with the scrubbing liquid;

the term "single-chamber incinerator" shall refer to refuse burning apparatus which has a simple furnace that discharges combustion products directly to an outlet flue;

the term "multiple chamber incinerator" shall refer to refuse burning apparatus whose furnace chamber discharges smoke and combustion gases into a settling chamber having multiple passes where coarse particulate matter is removed from the combusted gas stream by inertial separation with directional change before the combustion gases are finally discharged into the outlet flue of the incinerator,

the term "emission control device" shall refer to separating apparatus which limits the atmospheric discharge of particulate contaminants or condensable gases from any combustion process by removing these byproducts from the combusted gas stream;

With the aforestated objects in view, together with others which will appear as the description proceeds, the invention resides in the novel construction, assembly, and arrangement of parts which will be described more fully in the following discussion, illustrated in the drawings, and particularly pointed out in the claims.

In the drawings:

FIG. 1 is an isometric schematic drawing of a height-adjustable recirculation-type tank-mounted ejector scrubber unit with attached standard scrubber inlet, bypass and discharge duct branches as assembled for installation as the emission control system of an upgraded refuse incinerator.

FIG. 2 is a fragmentary rear corner view taken from the right end panel of the height-adjustable recirculation tank shown in FIG. 1 to illustrate the arrangement of adjustable support legs.

FIG. 3 is a fragmentary right corner view taken from the rear side panel of the height-adjustable recirculation tank shown in FIG. 1 to illustrate the arrangement of adjustable support legs.

FIG. 4 is a fragmentary sectional view taken across the right rear corner of the height-adjustable recirculation tank shown in FIG. 1 to illustrate the arrangement of adjustable support legs.

FIG. 5 is a front elevation of a height-adjustable recirculation-type tank-mounted ejector scrubber system with attached inlet, bypass and discharge duct branches.

FIG. 6 is a fragmentary right end elevation of the wet scrubber system shown in FIG. 5.

FIG. 7 is a fragmentary transverse section of the recirculation tank pump suction piping taken along line 1—1 of FIG. 6.

FIG. 8 is a side view of the submerged recirculation tank pump suction header taken along line 2—2 of FIG. 7.

FIG. 9 is an end view of the submerged recirculation tank pump suction header taken along line 6—6 of FIG. 8.

FIG. 10 is a front elevation of a height-adjustable drain-type tank-mounted ejector scrubber system with attached inlet, bypass and discharge duct sections.

FIG. 11 is a plan view of the drain-type tank-mounted ejector scrubber system taken along line 3—3 of FIG. 10 showing the system superimposed as installed onto the horizontal furnace section of a single-chamber incinerator.

FIG. 12 is a sectional elevation taken along line 4—4 of FIG. 11 showing the drain-type tank-mounted ejec-

tor scrubber system of FIG. 10 as installed to upgrade a single-chamber incinerator.

FIG. 13 is an exterior end view of the drain-type scrubber system discharge ductwork taken along line 5—5 of FIG. 11.

FIG. 14 is a fragmentary longitudinal section of an ejector-venturi gas scrubber unit which mounts a detachable motive-nozzle assembly.

FIG. 15 is a fragmentary section of the ejector-venturi gas scrubber unit of FIG. 14 which mounts an alternate detachable motive-nozzle assembly of smaller size.

FIG. 16 is a fragmentary section of the ejector-venturi gas scrubber unit of FIG. 14 which mounts a second alternate detachable motive-nozzle assembly of smaller size.

FIGS. 1-4 inclusive of the drawings illustrate the apparatus of a height-adjustable recirculation-type tank-mounted ejector scrubber system with integral inlet, bypass and discharge duct branches in an assembled configuration as typically installed to upgrade a single-chamber incinerator.

In FIG. 1, the numeral 13 designates a sheet metal recirculation tank having the gross external shape of a truncated right triangular wedge with a small rectangular prism cut transversely from its right base angle. Recirculation tank 13 contains a scrubbing liquid (such as water) which is supplied by a pump to spray nozzles for the gas scrubbing process, and then largely recovered from the clean gas stream for recirculation and reuse. Recirculation tank 13 is supported at the corners thereof by adjustable support legs which permit the tank to be installed at a convenient height above the floor at a particular location. When installed at the most appropriate height for a particular location, tank 13 serves as the extensible foundation for the system of standard pre-fabricated inlet, bypass and discharge ductwork upon which economy of installation so greatly depends.

A typical adjustable support leg arrangement as installed at the right rear corner of recirculation tank 13 is shown in FIGS. 2, 3 and 4. Adjustable perforated angle-iron support leg 14 is secured by two bolts 16 and nuts 17 to companion perforated angle-iron stringer 15. Perforated angle-iron stringer 15 is secured by welding or other means to right end panel 39 adjacent rear panel 40 of tank 13. The vertical position of each support leg 14 may be easily changed by removing bolts 16, and then re-bolting the legs in a new position.

During normal operations, a small continuous supply of make-up water enters tank 13 through supply line 22 and solenoid valve 23 (FIG. 1). A small continuous discharge of scrubbing liquid also leaves tank 13 from overflow branch 18 and is discharged into the building drainage system after flowing through drain header 19. The minor discharge of scrubbing water from tank 13 enters overflow branch 18 through an internal pipe which is fixed to control tank water level. The overflow process continuously drains off floating contaminants which are removed from the combustion gases during the scrubbing process. Sediment contaminants removed from incinerator gases by the scrubbing process settle into the bottom of tank 13, and may be released from the tank through drain line 20 into drain header 19 by opening drain valve 21.

Tank water is recirculated during the scrubbing process by pump 28, which is driven by motor 29 and at-

tached thereto by annular bracket member 30. Close-coupled pump unit 28-30 is mounted on shelf bracket 37, which is supported by pin connections and angle brace members 38 secured to the left-hand tank support leg assemblies. Suction flow proceeds from tank 13 into suction line 24, through valve 25, line strainer 26, flexible connection 27 and on into the suction of pump 28. Pressurized scrubbing water discharged by pump 28 flows through nozzle supply line 31, flexible connection 32 and past protective cut-out flow switch 33 before entering the body of ejector-venturi gas scrubber 34. Ejector-venturi gas scrubber unit 34 is common to the gas scrubber art.

During scrubbing operations, hot contaminated combustion gases enter cylindrical mesh intake basket 43, which would normally be made of corrosion-resistant metal. The discharge end of large-mesh intake basket 43 is connected to the inlet end of enlarged duct section 44, shown as installed to penetrate a section of the incinerator sidewall. The incinerator sidewall is typically composed of high-temperature refractory 45 and outside masonry material 47 separated by insulating air space 46. As shown by the exterior arrows, hot combustion gases may enter cylindrical mesh intake basket 43 from all directions through the free flow spaces of the large mesh. The large mesh intake basket prevents the random entry of large uncombusted or partly combusted material into the intake ductwork of the scrubber system.

Hot combustion gases flow from the furnace through cylindrical mesh intake basket 43 into enlarged inlet duct section 44, through concentric reducer section 48 and into regular scrubber inlet duct section 49. Scrubber inlet duct section 49 is connected to concentric reducer section 48 at the inlet end, and provides outlet flange 50 at its discharge end. An adjustable damper 51 is provided in inlet duct section 49 by which the flow of furnace gases through the ductwork may be regulated, thereby controlling the furnace draft in a throttling process. Scrubber inlet duct section 49 also includes a crossover connection with scrubber bypass duct branch 65 upstream of adjustable damper 51 as shown.

Outlet flange 50 of inlet duct section 49 and inlet flange 36 of ejector venturi gas scrubber 34 are connected together. Ejector-venturi gas scrubber 34 is connected to the top of recirculation tank 13 through discharge flange member 35 by bolting or other means. Internal spray nozzles within ejector-venturi gas scrubber 34 are supplied with pressurized scrubbing water from pump 28. During the scrubbing process, fine scrubbing water spray droplets entrain particulate contaminants from the combusted gas stream by impingement capture in the narrow throat section of the venturi scrubber unit. Condensable gas fractions may also be caused to condense from the dirty gas stream by the cooling attendant to the scrubbing process.

Separated particulate contaminants and condensed gas fractions are included in the liquid discharge of ejector-venturi scrubber unit 34. The separated contaminants with the liquid phase together with the cleaned combusted gas stream are discharged from the venturi scrubber into an internal separating element housed within tank 13. The contaminated liquid and the cleaned combustion gas streams are divided by the internal separating element, and the liquid stream with its contaminants falls into the tank. The cleaned com-

busted gas stream flows above the scrubbing water surface within recirculation tank 13, and flows toward the discharge outlet thereof.

It should be noted that gas seal end panel 41 extends from the top tank panel through the scrubbing water surface within tank 13. This arrangement prevents the escape of cleaned combustion gases, and channels their flow into the available discharge outlet of the tank. It should also be noted that, as shown at 42 the scrubbing water surface is exposed at the upper righthand end of the recirculation tank. Floatable contaminants enter the overflow piping at this location. This exposed scrubbing water surface 42 may also be used to house a float switch which controls the admission of make-up water into the tank.

The cleaned gas stream leaves recirculation tank 13 and flows into rectangular discharge duct section 52 through duct inlet flange 53, and on into long-radius duct turn 54. The cleaned gas stream then flows through horizontal discharge duct header section 55, which houses manual damper assembly 56 and provides a connection with bypass duct section 65 as shown. The discharge gas stream next flows from horizontal duct header section 55 into vertically disposed long-radius duct turn 57 and on into variable-height vertical duct section 58. The discharge gas stream next flows from variable-height vertical duct section 58 into vertical-to-horizontal short-radius duct turn 59 and on into variable-width horizontal duct section 60 into horizontally-disposed long-radius duct turn 61 and on into variable-depth horizontal duct section 62, from which flow proceeds into vertically-disposed gas flue outlet duct 63 for further discharge into the incinerator chimney flue. Elongate gas flue outlet duct 63 is normally installed within the gas flue in a recessed position flush with adjacent refractory lining of the chimney, and provides deflecting bars 64 across the discharge outlet thereof.

Bypass duct section 65 houses bypass damper assembly 66, and provides a cross-over connection between scrubber inlet ductwork 43-44 and 48-49 and scrubber discharge ductwork 55-63. Opening of bypass damper assembly 66 and closing off inlet modulating damper assembly 51 would permit furnace gases to flow from the incinerator into its chimney outlet duct 63 past the entire gas scrubber assembly 13-42 and around the incinerator gas flue refuse charging gate (normally closed).

Bypass duct section 65 with bypass damper assembly 66 may also be arranged in a different manner. Bypass duct section 65 may be provided with an individual inlet from the incinerator and have no direct connection with scrubber inlet ductwork 43-44 and 48-49. In this variation, furnace gases would be bypassed from the incinerator directly into discharge ductwork 55 and 57-63 inclusive, and discharged into the incinerator gas flue above the refuse charging gate (normally closed). This bypass arrangement would function similarly to the bypass arrangement in the embodiment of FIG. 1, but may be more advantageous in upgrading incinerator installations with peculiar arrangement or close clearances.

It should be noted that the inlet, bypass and discharge ductwork sections shown in the embodiment of FIG. 1 may be of standard manufacture, excepting for variable height duct section 58, variable-width duct section 60 and variable-depth duct section 62. Pre-fabricated inlet

ductwork would include elements 43-44 and 48-50, together with ejector-venturi gas scrubber assembly 33-36. Pre-fabricated discharge ductwork would include elements 52-57, 59, 61 and 63-64. Pre-fabricated bypass ductwork would include elements 65-66. This arrangement permits the entire recirculation-type ejector-venturi gas scrubber system having elements 13-44, 48-57, 59, 61 and 63-64 to be manufactured and assembled at a central location. Variable-length discharge duct sections 58, 60 and 62 can be easily cut and fitted at the job site by the installer. It is evident that the extensible scrubber system of FIG. 1 can be easily installed with its intake 43 elevated to a sheltered position adjacent the furnace ceiling in incinerators having different design and furnace heights, and thereby eliminate the considerable expense of individual fit-up and custom-type shop fabrication of scrubber system ductwork as now practiced in the art.

The embodiment of FIGS. 5, 6, 7, 8 and 9 discloses elements of a recirculation-type ejector-venturi gas scrubber system in greater detail, but omitting certain inlet and discharge duct sections. The recirculation-type scrubber system of FIGS. 5, 6, 7, 8 and 9 functions similarly to the scrubber system of FIGS. 1, 2, 3 and 4.

In FIGS. 5 and 6, the recirculation tank includes front side panel 67, top panel 68, inclined bottom panel 69, rear side panel 70, right end panel 71, left end panel 72, gas seal end panel 73 and watertight service and access cover 112 as elements thereof. Recirculation tank 67-73 is supported at each corner by an adjustable support leg 74, which is pinned to its adjacent companion fixed perforated angle-iron stringer 75 in the manner previously described. The bottom panel 69 of recirculation tank 67-73 slopes towards drain outlets provided by opposite welded couplings 80 to facilitate discharge of sediment contaminants by draining.

Tank water level is maintained for scrubbing operations by the admission of a small water flow from outside make-up supply line 109. Make-up supply line 109 includes solenoid valve 110 and orifice union 111. When solenoid valve 110 is open, a small flow of make-up water is discharged from the regulating orifice union 111 into the tank. This small flow of make-up water causes a surface overflow to carry off floating contaminants into overflow drain branch 76-79 inclusive. Overflow drain branch 76-79 includes submerged elbow 77 and connecting nipple 76, submerged elbow 77 being welded to the inside of right end panel 71 to enclose a perforation therethrough. Overflow drain branch 76-79 includes exterior elbow 78 and pipe member 79, exterior elbow 78 being connected to submerged elbow 77 through the perforation in right end panel 71 by a close pipe nipple or other suitable means. The submerged elbow-and-nipple assembly 76-77 is fixed within the tank to permit an even overflow of surface drainage from recirculation tank 67-73.

Recirculation tank 67-73 may be emptied by tank drain branch 82-83. Tank drain branch 82-83 may be arranged on either side of recirculation tank 67-73 as convenient by connection to either of tank drain couplings 80, with the unused coupling 80 being closed off by pipe plug 81. Tank drain couplings 80 are each welded to the exterior of their respective front and rear side panels to envelop a drain hole in the lower corner thereof. Tank drain branch 82-83 includes common pipe-and-elbow fittings and drain valve 83. Tank drain

branch 82-83 combines with overflow drain branch 76-79 by means of tee 84 to discharge drainage into drain header 85, and thence into the building sewage system.

In FIG. 7 is shown a fragmentary transverse sectional view of submerged recirculation tank suction piping taken along line 1-1 of FIG. 6. Perforated suction manifold pipe member 86 is mounted transversely below the recirculation tank water line, and secured by circumferential welds at the ends thereof to the inside tank surfaces of front side panel 67 and rear side panel 70. Front side panel 67 and rear side panel 70 have similar holes to match the inside flow area of suction manifold pipe 86 which are enveloped and sealed by the circumferential weldments. Exterior suction manifold couplings 87 are welded circumferentially to the exterior surfaces of front and rear side panels 67 and 70 respectively, opposite the ends of suction manifold pipe 86 as shown. One exterior suction manifold coupling 87 may be connected to pump suction piping as convenient to the installer, while the unused suction manifold coupling 87 is closed off by means of a common pipe plug 89.

Pump suction piping is connected as convenient to either of the exterior suction manifold couplings 87 as shown in FIG. 7. Tee member 88 is connected to exterior manifold coupling 87 by a common pipe nipple or other suitable means. The outside run of tee member 88 is closed by a common pipe plug 89, while the side outlet is connected to suction pipe member 90. The pump suction line includes piping 90, cut-out valve 91, strainer 93, male-and-female pipe unions 92 and 94, flexible connection 95 and other necessary fittings common to the piping arts.

Recirculated scrubbing water enters the perforations of suction manifold pipe 86 in an even pattern as shown by the exterior arrows. Scrubbing water flows directly into the pump suction line from suction manifold pipe 86, and on into the suction 96 of the actuating centrifugal pump 97. Perforations in the sides of suction manifold pipe 86 may be designed and distributed in any suitable pattern to promote development of a controlled state of turbulent mixing within the recirculation tank. This controlled state of turbulent mixing is intended to inhibit the separation of floatable contaminants from the scrubbing water by keeping them in suspension within major regions of the tank, and to promote the separation of floatable contaminants in the calm region of the exposed scrubbing water surface 113 adjacent the submerged overflow pipe section 76.

Centrifugal-type recirculation pump 97 is mounted on a shelf bracket member 98, the latter being secured by pin connections and angle brace members 99 to the left-hand tank support leg assemblies which include adjustable support legs 74.

Pressurized scrubbing water is discharged by recirculation pump 97 into ejector-scrubber nozzle supply piping 100. Nozzle supply piping 100 provides for inclusion of flexible connector 101 and protective flow switch 102, together with other fittings common to the piping arts.

Ejector-venturi gas scrubber unit 103 is mounted on the top of recirculation tank 67-73 by connectors through outlet flange 105. Hot dirty combustion gases enter ejector-venturi scrubber unit 103 through scrubber inlet flange 104, while pressurized scrubbing water,

supplied by pump 97 through nozzle supply piping 100, enters at the top of the scrubber unit. The front housing plate of ejector-venturi scrubber unit 103 has been partly removed in FIG. 5 to expose the internal spray nozzle. Scrubbed combustion gases and the contaminated liquid stream are discharged into recirculation tank 67-73 through outlet flange member 105.

Referring still to FIG. 5, the contaminated scrubbing liquid and scrubbed gas streams are discharged from ejector-venturi scrubber unit 103 through inertial separating element 106. Baffle-type inertial separating element 106 is internally mounted within recirculation tank 67-73 adjacent the discharge outlet of ejector-venturi scrubber unit 103. The separated contaminated liquid and scrubbed gas streams are discharged above the scrubbing water surface within the tank, as indicated by the dotted lines in FIG. 5. The contaminated scrubbing liquid stream is discharged onto the internal surface of left-end panel 72, and falls into the water body below. The scrubbed gas stream flows above the scrubbing water surface towards the tank discharge outlet adjacent gas seal end panel 73, as shown by the dotted arrow.

Particulate contaminants removed from the scrubbed gas stream fall as a sediment through the scrubbing liquid onto the inclined bottom panel and migrates towards the lower righthand tank edge adjacent drain couplings 80 (FIG. 6). Particulate sedimentary material may be discharged as drainage by opening drain valve 83 at periodic intervals during maintenance cleaning. During maintenance cleaning, tank access cover 112 (FIG. 5) may be removed to permit washing out of the tank by a hand-held water hose.

Light floatable contaminants removed from the scrubbed gas stream may be held in substantial suspension within the distributed turbulent mixing region of the scrubbing liquid caused by the pattern of perforations in suction manifold pipe member 86. The light floatable contaminants will be allowed to separate out from suspension in the scrubbing liquid by rising to the exposed scrubbing water surface 113 in the calm region adjacent overflow pipe member 76 at the upper right-hand edge of the recirculation tank.

A small continuous supply of make-up water from an outside source enters the recirculation tank through water supply line 109, solenoid valve 110 and orifice union 111. When the scrubber system is electrically actuated, solenoid valve 110 opens. The small orifice of orifice union 111 admits make-up water at rates of about 2-3 gpm which causes a continuous surface overflow into overflow drain branch 76-79 inclusive. The continuous overflow carries off floatable contaminants separated from the combustion gases by the wet scrubbing process.

Scrubbed and cleaned combustion gases are discharged from recirculation tank 67-73 into rectangular discharge duct 114 through duct entrance flange 115, which is secured to the discharge opening of tank 67-73 by connectors common to the fastening arts. The scrubbed combustion gases next flow into vertically-disposed long radius duct turn 116 from rectangular duct section 114, and flow on into horizontally-disposed discharge duct header section 117. Horizontally-disposed discharge duct header section 117 houses manual damper assembly 118.

Bypass duct section 119 with bypass damper assembly 120 (FIG. 5) is disposed between the inlet duct and

discharge duct sections upstream of the modulating inlet damper and downstream of the manual discharge damper in the same manner as illustrated in connection with FIG. 1. Certain inlet ductwork and discharge ductwork sections have been omitted for brevity and convenience in FIGS. 5 and 6, but may be similarly arranged as in the overall pattern of inlet and discharge ductwork shown in FIG. 1.

The modulating inlet damper assembly and bypass damper assembly 120 of the recirculation-type scrubber system disclosed in FIG. 5 would normally be positioned automatically by electrical operators which are part of the scrubber control system. These common devices are not shown and described for reasons of brevity, since they are not part of the applicant's contribution to the art.

Ejector-venturi scrubber unit 103 and inertial separating element 106 are already common to the gas scrubbing arts. These units are fabricated and distributed as single items of equipment by the manufacturer, and are normally custom-installed as part of an emission control system whose overall design and configuration varies in accordance with customer requirements. These component elements have not been assembled and distributed as parts of a complete recirculation-type emission controls system such as disclosed by the applicant. This complete emission controls system includes recirculation tank with adjustable support legs, integral fluid pump, ejector-venturi gas scrubber unit, baffle-type inertial separating element, together with pre-manufactured inlet, bypass and discharge ductwork integral to the system.

The illustrative embodiment of FIGS. 10, 11, 12 and 13 discloses elements of a drain-type tank-mounted ejector gas scrubber system which are actuated by pressurized water supplied from a municipal water system or other outside source. The drain-type scrubber system disclosed in FIGS. 10, 11, 12 and 13 has a general function similar to that of recirculation-type ejector gas scrubber systems excepting that the scrubbing water supplied by the outside source is continually discharged as drainage without re-use.

In FIGS. 10, 11 and 12 the drain tank includes front side panel 121, top panel 122, inclined bottom panel 123, rear side panel 124, right end panel 125, left end panel 126, watertight service port 127 and watertight access cover 128 as elements thereof. Drain tank 121-128 is supported at each corner by an adjustable support leg 129 which is pinned to the most adjacent fixed perforated angle-iron stringer 130. The fixed perforated angle-iron stringer 130 for each adjustable support leg 129 is secured to the outer tank shell by welding or other suitable means. Bottom panel member 123 is inclined towards the tank drain outlet enveloped by welded coupling 131 to facilitate drainage.

FIG. 10 is a front elevation of the drain-type tank-mounted scrubber system with its ductwork shown in typical installed position. FIG. 11 is a plan view of the drain-type scrubber system superimposed as installed onto the horizontal section of a single-chamber incinerator in a style practiced by those skilled in the incinerator art. FIG. 12 is a sectional elevation showing the drain-type scrubber system superimposed on the vertical section of a single-chamber incinerator.

During scrubbing operations, a continuous supply of pressurized scrubbing water from an outside source is admitted into ejector scrubber nozzle supply line 141

through solenoid valve 142 when the solenoid valve is actuated by the electrical control system. Hot contaminated combustion gases enter the scrubber intake ductwork from the furnace through cylindrical mesh intake basket 133. Scrubbed and cleaned combustion gases leave the scrubber system through discharge duct system 146-157 (FIG. 13). The contaminated scrubbing liquid is discharged to waste through drain line 132 (FIGS. 10 and 11).

The upgraded single-chamber incinerator 160-176 of FIG. 12 has a furnace space 160 supplied with combustible refuse from combination charging-and-gas-flue space 161. Combination charging-and-gas-flue space 161 normally extends from connection with the incinerator furnace at its lower end to its upper end above the building roof, and the flue design provides hopper doors at the various floor levels of the building through which refuse may be emptied into the flue. The refuse falls onto slidably disposed charging gate 162, which may be cyclically retracted out of the viewing plane of FIG. 12 by the incinerator control apparatus. When the stored refuse is released from the flue to fall onto the furnace grates 168 of upgraded single-chamber incinerator 160-176, it is normally ignited by an automatic gas burner actuated from the incinerator control system.

The incinerator is typically constructed with an outer wall of common masonry 165 with an inner heat-resistant refractory lining 163 separated by an insulating air space 164. The roof of the furnace chamber 160 is typically comprised of an inner heat-resistant refractory tile slab 166 covered by an outer layer of insulating refractory masonry 167. Both the furnace chamber 160 and the combination charging-and-gas flue space 161 may be lined with inner heat-resistant refractory lining 163 surrounded by exterior common masonry 165 with the separating air space 164. The upgraded single-chamber incinerator 160-176 provides original horizontal refractory hearth 169, sloping refractory hearth alterations 170, original firing door 171 with air port, ash pit space 172 below furnace grates 168, refractory lining of ash pit space 173, ash pit cleanout door 174 with adjustable register, foundation masonry 175 of furnace hearths 169 and firing space 176 between firing door 171 and furnace grates 168. Underfire air is admitted under furnace grates 168 through the register of ash pit door 174 to support the combustion process.

Hot contaminated combustion gases from furnace chamber 160 are drawn into cylindrical mesh intake basket 133 by ejector-venturi gas scrubber 137 and proceed into inlet duct 134 past closed bypass duct branch 158, pass open modulating damper assembly 135, and flow thence through inlet-duct outlet flange 136. Inlet duct 134 with attached mesh intake basket 133 extends through the incinerator sidewall 163-165 adjacent refractory tile roof slab 166 as shown. Inlet duct outlet flange 136 is connected by suitable means to inlet flange 138 of ejector-venturi gas scrubber assembly 137-140 inclusive.

Ejector-venturi gas scrubber assembly 137-140 includes ejector-venturi body shell 137 with its internal spray nozzle, gas inlet flange 138, discharge flange 139 and watertight nozzle-service port 140. Pressurized water from a municipal water system or other outside source is supplied to the internal spray nozzle of the ejector scrubber through nozzle supply line 141 after

solenoid valve 142 is electrically opened. A fine spray of high-velocity water droplets is discharged across the ejector throat to entrain the dirty gas stream. The spray droplets also capture particulates by wetted impingement, and causes the liquid condensation of condensable gas fractions from the combusted gas stream by the cooling process.

The scrubbed combustion gases and the contaminated scrubbing liquid stream are discharged into drain tank 121-128 through baffle-type inertial separating element 143 (FIG. 10) which is internally mounted within drain tank 121-128 adjacent the discharge of ejector-venturi gas scrubber assembly 137-140. The separated contaminated liquid and scrubbed gas streams are discharged above the drainage water surface, as indicated by the dotted lines in FIG. 10. The contaminated liquid stream is discharged onto the internal surface of left-end tank panel 126, and falls into the temporary drainage water body 145 below. The scrubbed gas stream flows above the temporary drainage water surface in gas flow space 144 towards the tank discharge outlet adjacent the upper right-hand edge as shown by the dotted arrows.

Particulate contaminants and condensed gas fractions removed from the combustion gas stream falls into temporary drainage water body 145. Temporary drainage water body 145 rises to that height necessary to overcome friction in the drain system, and maintains this height during steady state operations while being continuously drained off. Temporary drainage water body 145 provides an efficient water seal which prevents the substantial escape of scrubbed combustion gases through drain line 132.

Scrubbed combustion gases are discharged from drain tank 121-128 into rectangular discharge duct 146 through duct entrance flange 147. Duct entrance flange 147 is suitably secured to the discharge outlet of drain tank 121-128. The scrubbed combustion gases next flow into vertically-disposed long-radius duct turn 148, and thence through horizontally-disposed discharge duct header section 149.

Horizontally-disposed discharge duct header section 149 houses manual damper assembly 150, and provides connection with bypass duct section 158. The discharge gas stream flows past closed bypass duct section 158, thence into vertically-disposed long-radius duct turn 151, and on into variable-height vertical duct section 152. The discharge gas stream next passes from variable-height vertical duct section 152 into vertical-to-horizontal short-radius duct turn 153, and on into closely connected horizontally-disposed long-radius duct turn 154. The discharge gas stream proceeds from horizontally-disposed long-radius duct turn 154 into variable-depth horizontal duct section 155, from which the scrubbed gases proceed into vertically-disposed gas flue outlet duct 156 for further discharge into charging-and-gas flue 161. Elongate gas flue outlet duct 156 is normally installed within gas flue 161 in a recessed flush with adjacent refractory lining 163, and provides deflecting bars 157 across the discharge outlet thereof to prevent entry of refuse.

Bypass duct section 158 houses bypass damper assembly 159, and provides a cross-over connection between scrubber inlet ductwork 133-136 and scrubber discharge ductwork 149-156. When bypass damper assembly 159 is opened and modulating damper assembly 135 is closed, furnace gases may flow directly from

the furnace into the chimney flue around both the gas scrubber and refuse charging gate 162 (normally closed). It should also be noted that the bypass duct section 158 with damper assembly 159 would normally be open when the scrubber system is shut down, while the modulating inlet damper assembly 135 would be closed. The automatic operation of modulating inlet damper assembly 135 and bypass damper assembly 159 may be actuated from the scrubber controls system, and effected by electrical operators common to the controls arts.

Ejector-venturi unit 137 and inertial separating element 143 are already common to the gas scrubber arts. So far as applicant is aware, these component elements have not been assembled and distributed as parts of a complete drain-type emission controls system such as disclosed by the applicant. This complete emission controls system includes drain tank with adjustable support legs, ejector-venturi gas scrubber unit, baffle-type inertial separating element, together with pre-manufactured inlet, bypass and discharge ductwork integral to the system.

FIG. 14 is a fragmentary longitudinal section of a variable capacity drain-type ejector-venturi unit 177-182 inclusive, which is constructed of sheet metal and copied from an actual unpublished design. In FIG. 14 the flow of incinerator gases is induced by a high-velocity jet spray discharged from detachable motive-nozzle assembly 183-186 inclusive, which is supplied with pressurized scrubbing water from supply pipe 187. FIG. 15 is a fragmentary section of ejector-venturi unit 177-182 inclusive (FIG. 14) which mounts an alternate detachable motive-nozzle assembly of smaller size. FIG. 16 is a fragmentary section of ejector-venturi unit 177-182 inclusive (FIG. 14) which mounts a second alternate motive-nozzle assembly of smaller size. Any of the motive-nozzle assemblies 183-186 inclusive (FIG. 14), 189-192 inclusive (FIG. 15), or 194-197 inclusive (FIG. 16) may be alternately installed in ejector-venturi unit 177-182 inclusive to vary gas handling capacity of the scrubber unit by altering the motive-jet water supply rate to the ejector-venturi.

In FIG. 14 ejector-venturi unit 177-182 inclusive is comprised of annular receiving chamber 177, annular throat section 178, annular diffuser discharge section 179, flanged gas inlet duct connection 180, flanged annular inspection and service port 181, and flanged annular nozzle-assembly mounting spud 182. Nozzle assembly 183-186 inclusive is comprised of annular disc member 183 having pipe coupling 184 centered therewithin, close pipe nipple 185 and converging nozzle member 186, all of which are suitably secured together by means common to the plumbing art. The outer edge of annular disc member 183 seats against the matching flange of annular nozzle-assembly mounting spud 182. Nozzle assembly 183-186 is secured in operating position by detachable annular rim clamp 188 (shown in section), which is common in the fastening art. After nozzle assembly 183-186 has been securely mounted onto ejector-venturi unit 177-182 by closure of annular rim clamp 188, water supply pipe 187 would normally be connected to pipe coupling 184 to complete the installation work.

Nozzle supply assembly 189-192 inclusive (FIG. 15) is comprised of annular disc member 189 having pipe coupling 190 centered therewithin, pipe nipple 191 and converging nozzle member 192, all of which are suit-

able secured together by means common to the plumbing art. The outer edge of annular disc member 189 seats against the matching flange on annular nozzle-assembly mounting spud 182. Nozzle assembly 189-192 inclusive may be securely mounted onto ejector-venturi unit 177-182 by closure of the common detachable annular rim clamp 188 (shown in section). Nozzle assembly 189-192 inclusive is of smaller capacity than nozzle assembly 183-186 inclusive (FIG. 14), and may be alternately substituted therefor.

Nozzle supply assembly 194-197 inclusive (FIG. 16) is comprised of annular disc member 194 having pipe coupling 195 centered therewithin, pipe nipple 196 and converging nozzle member 197, all of which are suitably secured together by means common to the plumbing art. The outer edge of annular disc member 194 seats against the matching flange on annular nozzle-assembly mounting spud 182. Nozzle assembly 194-197 inclusive may be securely mounted onto ejector-venturi unit 177-182 by closure of the common detachable annular rim clamp 188 (shown in section). Nozzle assembly 194-197 inclusive is of smaller capacity than either of nozzle assembly 183-186 inclusive (FIG. 14) or nozzle assembly 189-192 (FIG. 15), and may be alternately substituted for either as the motive-nozzle assembly of ejector-venturi unit 177-182 inclusive.

The alternate motive nozzle assemblies disclosed in FIGS. 14, 15 and 16 are each designed in cognizance with known spreading properties of a fluid jet, so the theoretical spread of each liquid jet will equal the diameter of ejector-venturi throat 178 within the length of the throat section. The approximate outline of the theoretical spread of each liquid jet is indicated in phantom in each of FIGS. 14, 15 and 16. That motive-jet spread should equal ejector-venturi throat diameter within the throat length is known by experiment to be necessary for achieving usefulness in the design of ejectors. It is also necessary in the design of interchangeable motive nozzle assemblies for a common ejector-venturi unit that the nozzle assemblies have common spreading characteristics if useful gas handling capacities at different motive-fluid flow rates are to be realized.

The advantages of the invention for ease of manufacture and convenience of installation can now be emphasized. Drain-type tank-mounted ejector-venturi gas scrubber system 121-157 (FIG. 11) can be manufactured and assembled almost entirely of identical components for a given gas handling capacity range excepting for the job-site fit-up of variable-height, variable-width and variable-depth discharge duct sections. Similarly recirculation-type tank-mounted ejector-venturi gas scrubber system 67-120 with inlet and discharge ductwork similar to that of FIG. 1 can be manufactured and assembled almost entirely of identical components for a given gas handling capacity range excepting for the job-site fit-up of variable-height, variable-width and variable-depth discharge duct sections. The vertically-disposed ejector-venturi gas scrubber unit of each scrubber system is an integral part of its inlet ductwork, and supports its horizontally-disposed intake duct branch at the approximate height of the refractory furnace ceiling. Either of pre-manufactured recirculation-type scrubber system 67-120 (FIG. 7) or drain-type scrubber system 121-157 may be conveniently installed with the furnace intake elevated to the

correct height adjacent the refractory furnace roof without serious regard for variations in incinerator geometry. The adjustable support legs of either scrubber system are extended and fixed at the correct length for the particular incinerator installation, and the scrubber system installation may proceed with facility. Either scrubber system may be installed with either front or rear tank sides adjacent the incinerator as convenient, and the fit-up of standard duct sections proceeds with dispatch in accordance with the arrangements of a particular incinerator.

The teachings of the invention with respect to extensible support legs and pre-manufactured standard ductwork may also be applied to wet scrubber systems of other design. In some of these designs the principal system actuator may be an induced draft type of fan, as applied to the incinerator combustion system. In other designs, the system may include both an induced draft fan and a jet spray pumping system as principal actuators. In either of these applications, the wet scrubber system would include the combination of extensible support legs mounted on the scrubber frame or shell together with a system of standard pre-manufactured inlet, bypass and discharge ductwork sections made possible by the adjustable height feature of the scrubber body.

While I have shown and described certain specific embodiments of the present invention, it will be readily understood by those skilled in the art that I do not wish to be limited exactly thereto, since various modifications may be made without departing from the scope of the invention as defined in the appended claims.

I claim:

1. Combined air pollution control apparatus for refuse incinerators having different ceiling heights and geometry comprising a height-adjustable wet gas scrubber system having in combination: an elongated plenum comprising a horizontal settling chamber having fluid passageways therein for horizontal transit with flow reversal of cleaned combustion gases and providing a receptacle for separated scrubbing water; said horizontal settling chamber providing inlet and outlet openings thereon for connection with inlet and outlet gas conduits; extensible support legs having alternate connecting elements and connections with said horizontal settling chamber whereby said extensible support members may be disposed in alternate positions to support the said settling chamber an adjustable distance with respect to the floor; a fluid pump comprising an ejector-venturi gas scrubber unit having an integral motive nozzle disposed to impel the flow of combustion gases through said extensible wet gas scrubber system by means of a high-velocity motive-jet of scrubbing water; said ejector-venturi gas scrubber unit substantially supported by connection with said horizontal settling chamber and disposed to discharge downwardly thereinto; a baffle-type separating element disposed within said horizontal settling chamber adjacent the outlet of said ejector-venturi gas scrubber unit to discharge separated liquid and gaseous streams horizontally therefrom; means for supplying pressurized scrubbing water to the motive nozzle of said ejector-venturi fluid pump; valve means for selectively admitting pressurized scrubbing water into the water supply conduit of said motive nozzle; a drainage conduit communicating with a liquid waste outlet of said horizontal settling chamber and disposed to discharge separated liquids therefrom;

a gas inlet conduit disposed to communicate between the gas outlet of a refuse incinerator and the inlet of said ejector-venturi gas scrubber unit, the said gas inlet conduit substantially supported by connection with said ejector-venturi fluid pump; and a gas discharge conduit disposed for communication between the gas outlet of said horizontal settling chamber and the discharge flue of a refuse incinerator, said gas discharge conduit substantially supported by connection with said settling chamber; whereby the said horizontal settling chamber and its extensible support members comprise a height-adjustable foundation for the substantial support of the said ejector-venturi gas scrubber unit and the said inlet and outlet gas handling conduit.

2. The extensible wet gas scrubber system of claim 1 wherein valve means are disposed in drainage conduit of said horizontal settling chamber; the lower section of said horizontal settling chamber being disposed to provide a storage reservoir for recirculated scrubbing liquid; a liquid pump; pump suction conduit communicating between the liquid reservoir of said horizontal settling chamber and the suction inlet of said liquid pump; and a pump discharge conduit communicating between the pressure outlet of said liquid pump and the motive nozzle of said ejector-venturi gas scrubber unit.

3. The extensible wet gas scrubber system of claim 1 wherein valve means are disposed in drainage conduit of said horizontal settling chamber; the lower section of said horizontal settling chamber being disposed to provide a storage reservoir for recirculated scrubbing liquid; a liquid pump; a submerged perforated conduit disposed beneath the surface of said liquid reservoir and having exterior ends which penetrate exterior boundaries of said horizontal settling chamber so that pump suction connections may alternately be made to alternate exterior ends of said submerged perforated conduit; and a pump discharge conduit communicating between the pressure outlet of said liquid pump and the motive nozzle of said ejector-venturi gas scrubber unit.

4. Combined air pollution control apparatus for refuse incinerators having different ceiling heights and geometry comprising a height-adjustable wet gas scrubber system having in combination: an elongated plenum comprising a horizontal settling chamber having fluid passageways therein for horizontal transit with flow reversal of cleaned combustion gases and for storage of recirculated scrubbing liquid; said horizontal settling chamber providing inlet and outlet openings thereon for connection with inlet and outlet gas conduits; extensible support legs having alternate connecting elements and connections with said horizontal settling chamber whereby said extensible support members may be disposed in alternate positions to support the said settling chamber an adjustable distance with respect to the floor; a fluid pump comprising an ejector-venturi gas scrubber unit having an integral motive nozzle disposed to impel the flow of combustion gases through said extensible wet gas scrubber system by means of a high-velocity motive-jet of scrubbing water;

said ejector-venturi gas scrubber unit substantially supported by connection with said horizontal settling chamber and disposed to discharge downwardly thereinto; a baffle-type separating element disposed within said horizontal settling chamber adjacent the outlet of said ejector-venturi gas scrubber unit to discharge separated liquid and gaseous streams horizontally therefrom; a liquid pump; a pump suction conduit communicating between the liquid reservoir of said horizontal settling chamber and the suction inlet of said liquid pump; a pump discharge conduit communicating between the pressure outlet of said liquid pump and the motive nozzle of said ejector-venturi gas scrubber unit; a gas inlet conduit disposed to communicate between a gas outlet of a refuse incinerator and the inlet of said ejector-venturi gas scrubber unit, said gas inlet conduit substantially supported by connection with said ejector-venturi fluid pump; and a gas discharge conduit disposed to communicate between the gas outlet of said horizontal settling chamber and a discharge flue of a refuse incinerator, said gas discharge conduit substantially supported by connection with said settling chamber; whereby the said horizontal settling chamber and its extensible support members comprise a height-adjustable foundation for the substantial support of the said ejector-venturi gas scrubber unit and the said inlet and outlet gas handling conduit.

5. The extensible recirculation-type wet gas scrubber system of claim 4 wherein said liquid pump is supported by mountings secured to said horizontal settling chamber, thereby providing an integral adjustable foundation for said liquid pump member.

6. The extensible recirculation-type wet gas scrubber system of claim 4 wherein a submerged perforated conduit is disposed beneath the surface of said liquid reservoir and having exterior ends which penetrate exterior boundaries of said horizontal settling chamber so that pump suction connections may alternately be made to alternate exterior ends of said submerged perforated conduit; and said pump suction conduit being disposed to communicate between the suction inlet of said liquid pump and the alternate exterior ends of said submerged perforated conduit.

7. The extensible wet gas scrubber system of claim 1 wherein a common motive-nozzle mounting is disposed centrally within said receiving section; a plurality of motive nozzles each having different size and liquid capacity at constant supply pressure with respect to each other and similar means for alternately connecting each nozzle member in operating position to the said common motive-nozzle mounting, means for supplying pressurized scrubbing water to any selected individual motive-nozzle member of the said plurality from a common pressure source; whereby alternate motive-nozzle members of the said plurality having different liquid capacities may be selectively disposed from the said common nozzle mounting in operating position to impel combustion gases through the said ejector-venturi fluid pump at different gas flow rates.

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