Jan. 6, 1970 N. KLEIN ET AL 3,487,620

SMOKE CLEANING APPARATUS

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FIG. 2.

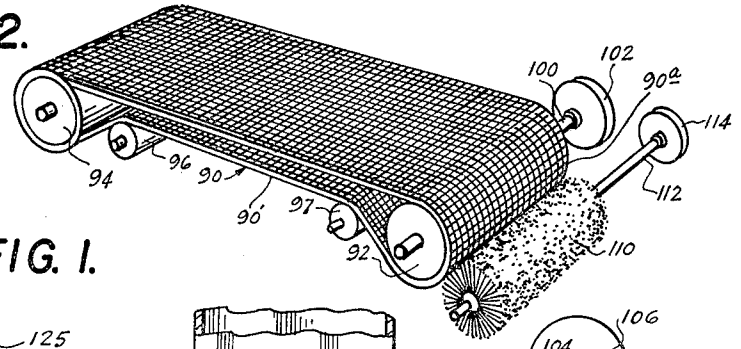
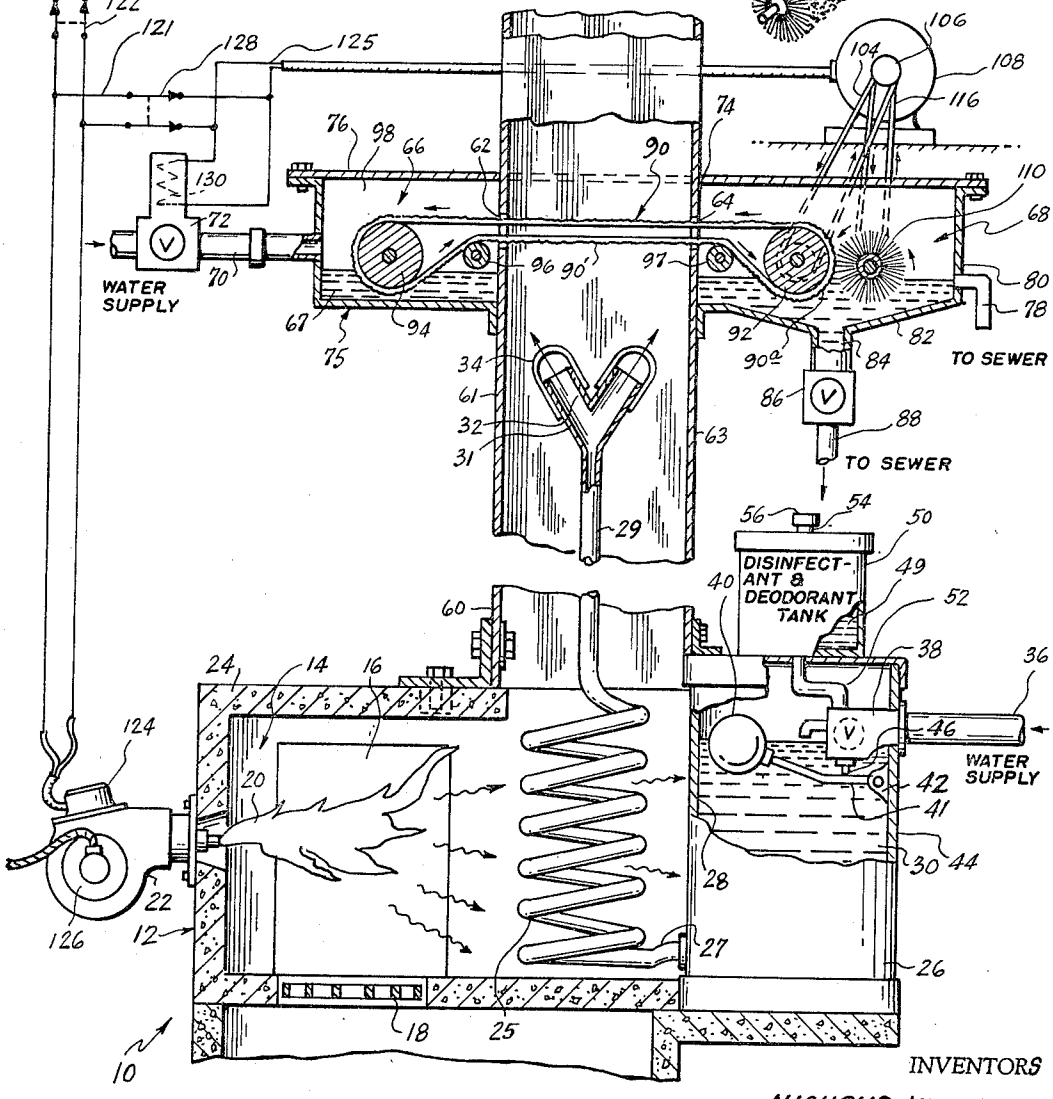


FIG. 1.



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SMOKE CLEANING APPARATUS

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FIG. 3.

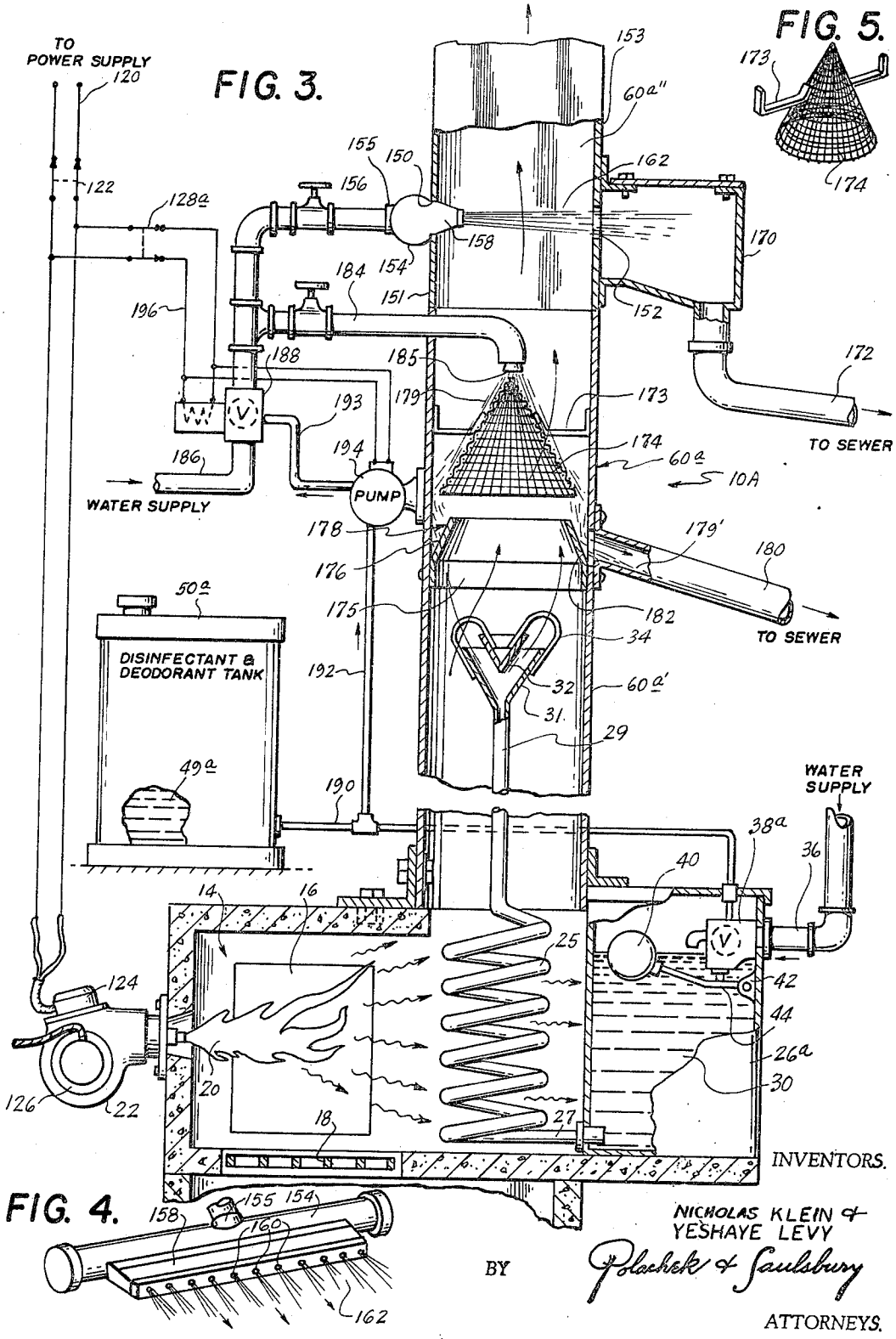

FIG. 5.

FIG. 4.

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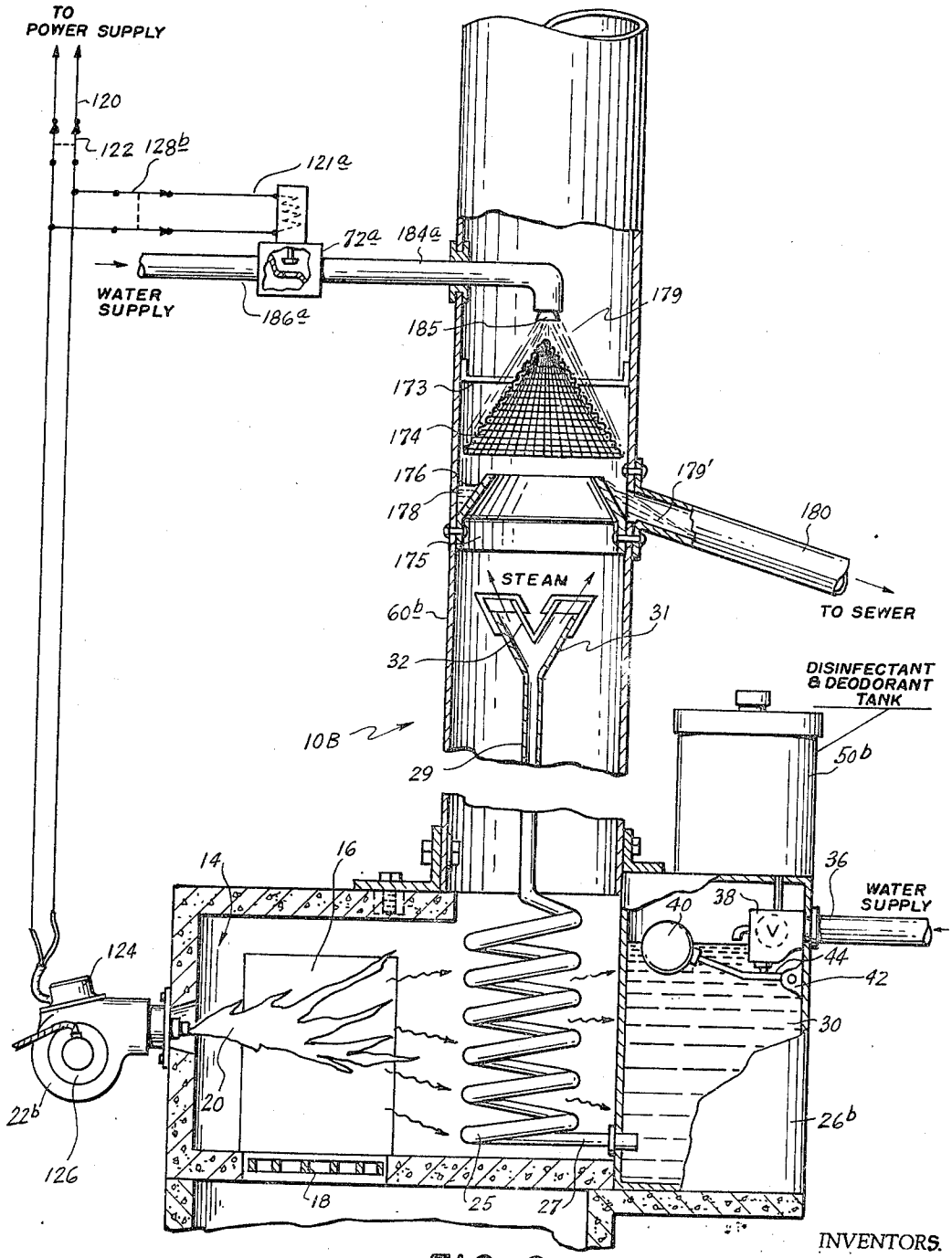

FIG. 6.

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SMOKE CLEANING APPARATUS

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U.S. Cl. 55—222 1 Claim

ABSTRACT OF THE DISCLOSURE

Apparatus for filtering and washing smoke containing solid particles passing upwardly through a smoke stack is described. A steam generating heat exchanger is located in a combustion chamber where the smoke is generated. A mixture of smoke and steam passes up the smoke stack to a water-cooled screen where the steam condenses to water drops entrapping solid particles. The screen and water film thereon hold back the solid particles. The waste water is collected in a trough and is drained off from the trough. The screen can be a double layer moving screen belt continuously washed by a brush in the trough. The screen can be stationary and conical in form. A disinfectant-deodorant such as ozone or the like, is volatilized in the heat exchanger and is discharged with the steam into the smoke in the stack.

The invention relates to the art of smoke cleaning apparatus and more particularly is concerned with means for continuously cleaning smoke generated in a garbage and refuse incinerator so that the fumes discharged from a stack are free of solid particles.

Heretofore apparatus for reducing air pollution caused by smoke discharging incinerators has been limited to filters of various kinds, generally screens placed at outlets of the smoke stacks. Such filters have not been found satisfactory because they quickly become clogged and reduce the draft required to operate the incinerators effectively. If clogging is to be avoided, the filter mesh is of such coarseness that an excessive amount of solid particles are discharged from the stack.

The present invention is directed at solving this problem by washing the smoke in a draft of steam and draining off the condensed steam containing solid particles removed from the smoke.

According to the invention the heat of combustion of the incinerator is used to generate steam in a coiled, tubular heat exchanger continuously supplied with fresh water. The steam travels up the smoke stack or chimney of an incinerator and impinges on a water-cooled moving screen which travels across the stack. The screen is scrubbed continuously and polluted water containing solid particles is drained off to a sewer. A disinfectant and deodorant is mixed with the water entering the heat exchanger and is volatalized therein. In a modification of the invention, a two-stage smoke cleaning apparatus is provided. In a first stage, cold water is discharged on a stationary conical screen which catches solid particles in the smoke. The condensed steam and solid particles are drained off at the first cleaning stage. In the second stage, a field of finely divided streams of cold water is maintained across the stack. Any fine particles in the smoke passing through the rapidly moving streams is caught and carried away to a drain. In a simplified form of the invention, second cleaning stage is omitted. In all forms of the invention, the discharge of the disinfectant-deodorant into the water supplied to the heat exchanger is coordinated with discharge of the water into a mixing tank which supplies the heat exchanger.

For further comprehension of the invention, and of the objects and advantages thereof, reference will be had to the following description and accompanying drawings and to the appended claims in which the various novel features of the invention are more particularly set forth.

In the accompanying drawings forming a material part of this disclosure:

FIG. 1 is a vertical sectional view, partially diagrammatic in form and with parts omitted, of a smoke cleaning apparatus embodying the invention.

FIG. 2 is a perspective view of a roller screen employed in the apparatus of FIG. 1.

FIG. 3 is a vertical sectional view similar to FIG. 1 showing a two-stage smoke cleaning apparatus.

FIG. 4 is a perspective view of water discharge manifold employed in the apparatus of FIG. 3.

FIG. 5 is a perspective view of a filter screen employed in the apparatus of FIG. 3.

FIG. 6 is a vertical sectional view similar to FIGS. 1 and 3, showing another smoke cleaning apparatus.

Referring first to FIG. 1, there is shown apparatus **10** having a generally rectangular furnace **12** in which is a chamber **14**. Garbage and refuse is deposited in chamber **14** via a side door **16** on to a grate **18**. The contents of the chamber are incinerated by flames **20** emitted by a fuel oil or gas burner **22** mounted on side wall **24**. Located in an axially vertical position in chamber **14** is a heat exchanger **25** comprising an axially vertical, helically coiled tube to obtain maximum heat transfer from chamber **14**. The lower end **27** of the tube is connected to a water storage tank **26** which has a side wall **28** exposed to chamber **14** so that the water **30** in tank **26** is preheated. The upper end **29** of the tube is axially vertical and terminates in a funnel **31**. A conical deflector **32** is held in the open mouth of the funnel by brackets **34**.

The water **30** is fed to tank **26** via a supply pipe **36** connected to a mixer valve **38**. A ball float **40** is carried by arm **41** pivotally supported by bracket **42** at side wall **44** of the tank. When the level of water in tank **26** falls, operating member **46** of the valve **38** is released by arm **41** supporting float **40** so that water is discharged into the tank. A liquid disinfectant and deodorant **49** is contained in a storage container or tank **50** on top of tank **26**. Outlet pipe **52** of tank **50** communicates with an inlet of mixer valve **38**. Thus each time water is discharged into tank **26** the disinfectant-deodorant **49** is discharged at a predetermined rate into tank **26** along with water **30**. Tank **50** has a filler tube **54** and removable cap **56**.

Funnel **31** and the upper end **29** of the heater tube are located in the axially vertical rectangular smoke stack or chimney **60** mounted on top of the furnace **12**. The stack has opposed slots **62**, **64** formed in opposite sides **61**, **63**. Surrounding these slots is a generally rectangular trough **75** having two communicating chambers **66** and **68**. Cold water **67** is supplied to these chambers via water supply pipe **70** controlled by electromagnetic valve **72**. Pipe **70** communicates with side wall **72** of the trough. The smoke stack **60** extends upwardly through hole **74** in cover plate **76** of the trough. A drain pipe **78** is located at side wall **80** of the trough above the bottom of the trough and conveys dirty waste water to a sewer. The bottom **82** of the trough is formed with a sump **84** having a valve **86** which can be opened to discharge water containing settled particles to a sewer via drain pipe **88**.

An endless mesh screen belt **90** extends across the stack and through slots **62**, **64** into chambers **66**, **68** of the trough. Screen belt **90** is carried on a drive roller **92** and idler roller **94** at opposite end loops. Screen belt **90** is horizontal and the rollers are axially horizontal. The bottom course **90'** of the screen belt is supported on idler rollers **96**, **97**. The rollers are journaled in opposite verti-

cal walls **98** of the trough. Roller **92** has a drive shaft **100** carrying a pulley **102** best shown in FIG. 2. A drive belt **104** is engaged on pulley **102** and on drive pulley **106** of motor **108**. Adjacent the roller **92** is an axially horizontal cylindrical brush **110**. The brush has a drive shaft **112** carrying a pulley **114** which is smaller than pulley **102**. Belt **116** is engaged on pulley **114** and on drive pulley **106** of the motor. The brush bears against right end loop **90***a* of the screen belt **90** as indicated in FIGS. 1 and 2. Since pulley **114** is smaller than pulley **102**, the brush will rotate faster than roller **92** and will effectively brush the end **90***a* of the screen belt **90**. Both rollers **92**, **94** and brush **110** are at least partially immersed in water **67** and all rotate in the same direction.

The electrical system of the apparatus includes power supply wires **120** connected via a double-pole switch **122** to ignition **124** and blower **126** of the burner **22**. Connected to wires **120** via wires **121** and another double-pole switch **128** is coil **130** of the electromagnetically operated valve **72**. Also connected to wires **121** are wires **125** which supply power to motor **106**. It will be apparent from an inspection of FIG. 1, that the burner **22** is actuated when switch **122** is closed. Both motor **106** and valve **72** are actuated when both switches **122** and **128** are closed.

In operation of the apparatus **10**, when the burner is operating, flame **20** will heat the heat exchanger **25** which is supplied with water **30** from tank **26**. The water in heat exchanger **25** will be turned to steam and the disinfectant-deodorant will evaporate. The steam will mix with smoke produced by combustion of refuse in compartment **14** of the furnace and by combustion of fuel burned in burner **22**. The mixture of smoke and steam is deflected to the sides of the smoke stack by funnel **31**. The mixture of smoke and steam impinges on the moving screen belt **90** which catches solid particles in the smoke and steam. The steam condenses to water drops which wash the smoke leaving it substantially free of solid particles as it passes through the lower and upper courses of the screen. The screen is kept cold by the cold water in trough **75**. Furthermore the interstices in the screen are closed by a film of water which serves to wash and strain the smoke and fumes passing through the screen. The screen is kept in continuous motion as long as the burner **22** is operating since they are connected in a common power supply circuit. In addition water **67** is fed continuously to trough **75** while the screen belt **90** is moving. As the lower course **90'** of the screen belt reaches the brush **110** the belt is cleaned and the particles pass into the water **67**. Floating particles are drawn off via drain pipe **78**. Heavier particles which sink are collected in sump **84** and are periodically drawn off when valve **86** is opened.

Each time the ball **40** descends sufficiently to open valve **38**, a mixture of disinfectant-deodorant **49** and water **30** is discharged into tank **26** to keep it filled. The rising ball automatically shuts off the supply of water to tank **26** when the tank is filled.

By the arrangement described, the gases discharged from the top of stack **60** are scrubbed clean of solid particles. The screen **90** serves as a two-stage cleaner. At the first stage, the solid particles are stopped by the fine mesh of the screen and the water film on lower course **90'** and the steam partially condenses. At the second stage, when the smoke and steam mixture reaches upper course **90''** condensation of the steam is completed and the smoke is scrubbed again by the fine mesh of the screen and the water film carried by the upper course.

The gas or fumes discharged from the stack **60** retain the disinfectant which sterilizes the fumes and the deodorant which imparts a pleasant aroma to the fumes. The apparatus thus operates automatically and effectively to accomplish its intended purposes.

FIGS. 3, 4 and 5 show another system **10A** which is generally similar to system **10** and corresponding parts are identically numbered. In system **10A**, the stack **60***a* has a lower cylindrical portion **60***a'* and a rectangular upper section **60***a''* provided with opposed slots **150**, **152** in opposite sides **151**, **153**. A tubular manifold pipe **154** closed at opposite ends is mounted at slot **150**. This pipe, as clearly shown in FIGS. 3 and 4, has an inlet fitting **155** to which water supply pipe **156** is connected. The pipe **154** has a long, narrow discharge nozzle **158** having many openings **160**. The water **162** which is discharged by nozzle **158** forms a muultiplicity of closely spaced overlapping fine streams which pass transversely across rectangular section **60***a''* and out through slot **152**. The water **162** is collected in a drain trough **170** and passes to a sewer via a drain pipe **172**.

Just below the rectangular section **60***a''* in cylindrical lower portion **60***a'* is a conical mesh screen **174** axially vertical and held by bracket arms **173**. The screen **174** is apically uppermost. Just below screen **174** is a baffle ring **175** which has a tapered annular upper portion **176**. An annular trough **178** is defined between ring portion **176** and the inner side of stack portion **60***a'*. A drain pipe **180** extends laterally and downwardly from opening **182** in the side of stack portion **60***a'* at trough **178**. Water **179** is discharged in a conical spray on the conical mesh screen **174** from a water discharge pipe **184** extending radially of stack portion **60***a'* and provided with a water spreader **185**. Both pipes **156** and **184** are connected to a common water supply pipe **186** via an electromagnetically operated mixer valve **188**.

Tank **50***a* containing the disinfectant-deodorant **49***a* is fed via pipe **190** to mixer valve **38***a* in water storage tank **26***a*. Branch pipe **192** supplies the disinfectant-deodorant via a pump **194** and pipe **193** to mixer valve **188**.

In the electrical system of the apparatus, both valve **188** and pump **194** are connected via wires **196** and switch **128***a* to the power supply wires **120**. In operation of the apparatus screen **174** and ring **175** constitute the first stage of a two-stage cleaning system. The mixture of steam and smoke rising in the lower portion **60***a'* of the smake stack are filtered by both the fine mesh of stationary screen **174** and the film of water which flows around and down the screen to trough **178**. The steam is also condensed to water drops which condense on the fine particles which are drained into channel **178**. There the dirty water **179'** is drained off through drain pipe **180**.

In the second stage of cleaning, the gas fumes pass through the fine streams of water spray **162**. Condensation of steam is completed as well as entraining of fine particles which are drawn off via trough **170** and drain pipe **172**.

The pump **194** is activated while the water is being discharged in both the first and second cleaning stages of the apparatus so that the water at both stages contains the disinfectant and deodorant. The volatile disinfectant and deodorant is carried upwardly in the gases discharged from the top of smoke stack section **60***a''*.

The system **10A** is almost fully as effective as system **10** except that there is only one stage of mechanical filtering by a mesh screen **174** and the mesh screen is stationary. In system **10**, the screen belt **90** moves and is cleaned in the stationary water bath in trough **75**, while in system **10A** the screen **174** is stationary and is cleaned by the flowing water film passing down and around the screen. Since the second cleaning stage employs water containing disinfectant and deodorant, the fumes discharged from the smoke stack will contain fresher disinfectant and deodorant which is desirable.

In FIG. 6 is shown system **10B** which is generally similar to systems **10** and **10A** and corresponding parts are identically numbered. In system **10B**, the disinfectant-deodorant is supplied to tank **26***b* from tank **50***b* as in system **10**. The conical filter screen **174** and baffle ring **175** are mounted in stack **60***b* which is cylindrical throughout. Water is supplied by supply pipe **186***a* via valve **72***a* and pipe **184***a*. Wires **121***a* are connected in

parallel with the power supply to oil burner **22***b*. Thus when burner **22***b* is running, scrubbing water **179** is discharged upon screen **174** as in system **10**A. System **10**B is somewhat simpler in structure than systems **10** and **10**A for installations where a more economical apparatus is desired and where the smoke scrubbing load is less severe.

All the arrangements of apparatus described operate automatically and require only routine inspection and replenishment of disinfectant-deodorant, and setting of the manually controllable valves.

What is claimed is:

1. Apparatus for removing solid particles from smoke generated by a furnace, comprising a tubular heat exchanger containing circulating water disposed in a chamber in the furnace for turning the water to steam by heat in said chamber; a vertical smoke stack communicating with said chamber; said heat exchanger having an outlet in said smoke stack so that steam emitted by the heat exchanger mixes with smoke containing solid particles, in the smoke stack; a fine mesh screen in the smoke stack in the path of upward travel of the mixture of smoke and steam; said screen including a stationary conical screen member axially aligned with the smoke stack positioned above said heat exchanger; a source of fresh cold water including means in said stack arranged to deposit a film of cold water on the screen so that the screen causes condensation of steam impinging thereon to drops of water containing said solid particles; both the screen and the film of water on the screen cooperating in removing further solid particles from the smoke passing through the screen; an annular trough disposed in said stack beneath said screen to collect the water passing from said screen containing solid particles removed from the smoke; a drain communicating with the trough including an opening in said stack for draining off the water containing solid particles removed from the smoke; a manifold pipe mounted at the smoke stack above said screen and connected to said source of cold water, said manifold pipe having a horizontal nozzle with a multiplicity of openings in the smoke stack arranged to discharge a multiplicity of fine streams of water across the smoke stack for catching any further particles in the smoke which have passed through the screen; another trough disposed at the smoke stack wall including an opening in the wall of the stack aligned with said nozzle openings to collect the water passing across the smoke stack from said nozzle; and another drain at said other trough arranged to carry away the water collected in said other trough.

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U.S. Cl. X.R.

55—233, 234, 243, 279, 290, 354, 521; 261—117, 118, 126; 110—119; 266—15