United States Patent

Gardenier

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[54] **PROCESS AND APPARATUS FOR CLEANING AND PUMPING CONTAMINATED INDUSTRIAL GASES**

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[*] Notice: The portion of the term of this patent subsequent to Oct. 19, 1988, has been disclaimed.

[22] Filed: **June 16, 1970**

[21] Appl. No.: **46,793**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 842,635, July 17, 1969, Pat. No. 3,613,333.

[52] **U.S. Cl.** ....**55/84,** 23/277 C, 55/89, 55/93, 55/222, 55/223

[51] **Int. Cl.** **B01d 47/10**

[58] **Field of Search**..........55/85, 89, 90, 93, 84, 222, 55/223, 228, 257; 23/277 C

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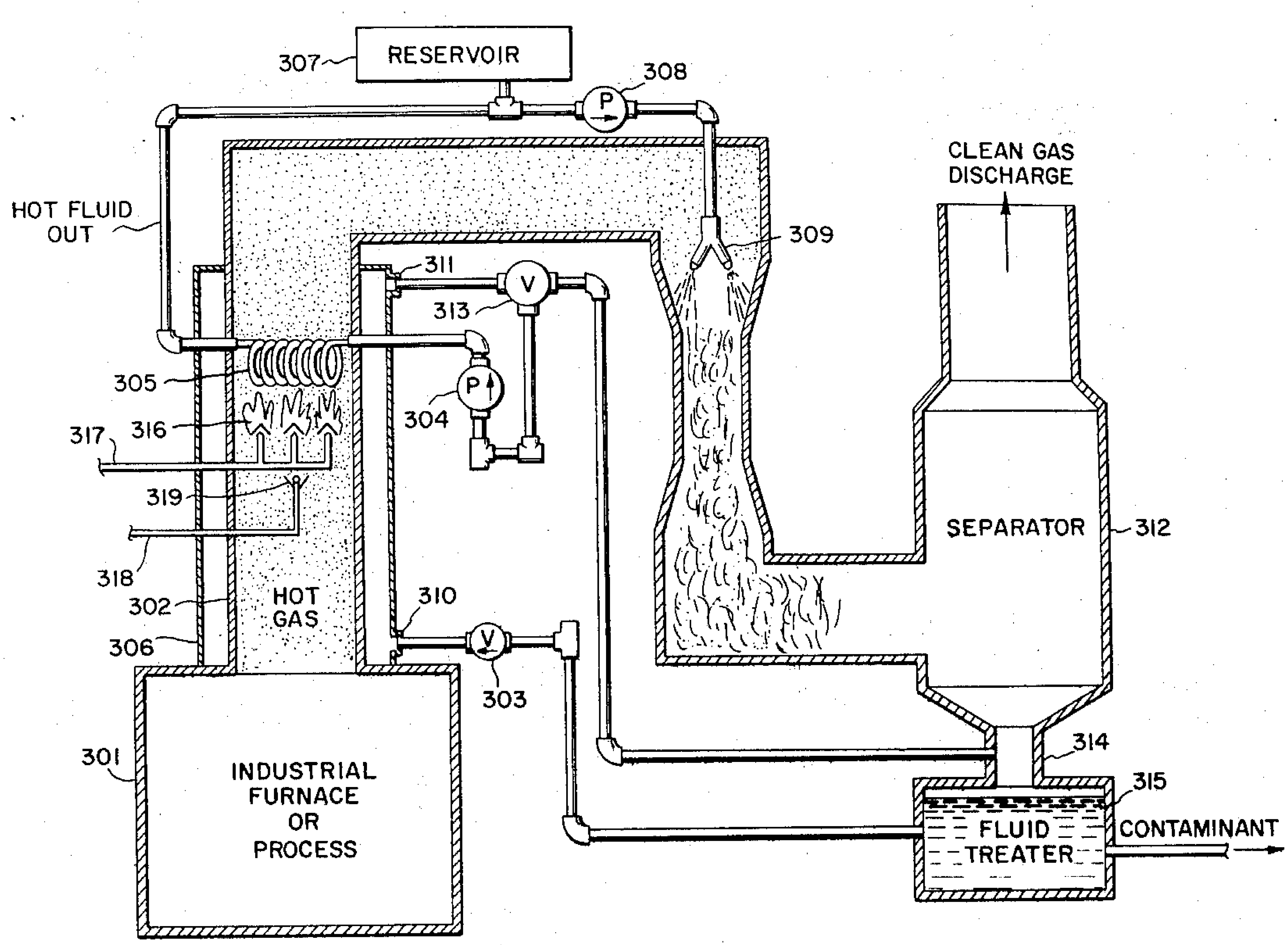
[57] **ABSTRACT**

Process and apparatus for removing contaminants from and pumping a gas stream comprising indirectly heat exchanging the gas and a liquid, introducing the liquid under conditions of elevated temperature and pressure in vaporized and atomized form into the gas, mixing same thereby entrapping the contaminants, and separating clean gas from the atomized liquid containing the contaminants. In one embodiment, a water jacket surrounds the hot gas conduit and serves both to cool the hot gases and to pre-heat the cleansing liquid. Also disclosed is an auxiliary mechanism for heating the cleansing liquid before injection into the gas stream. The combustibles in the contaminated gases may be used for such heating.

18 Claims, 5 Drawing Figures



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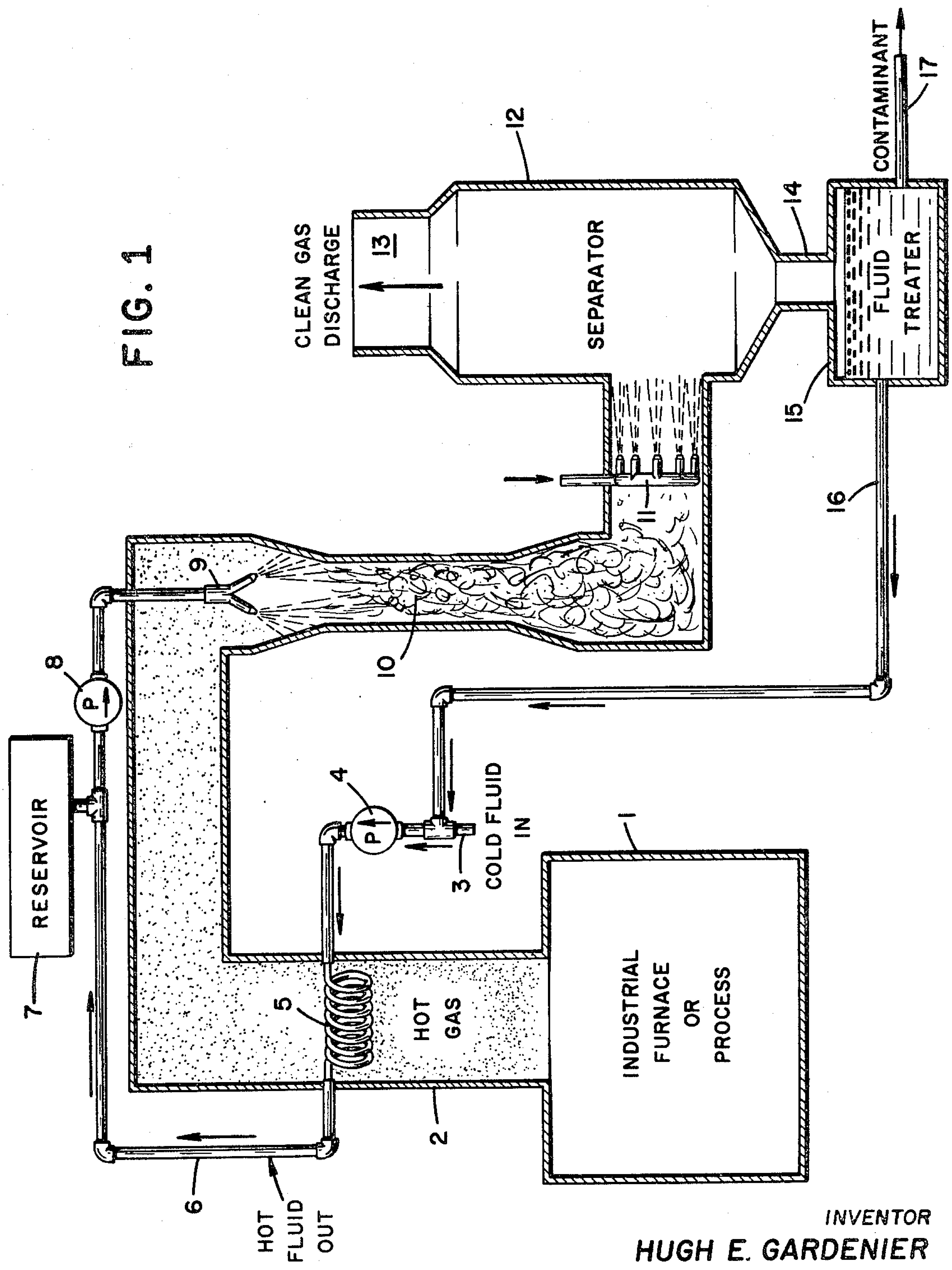

FIG. 1

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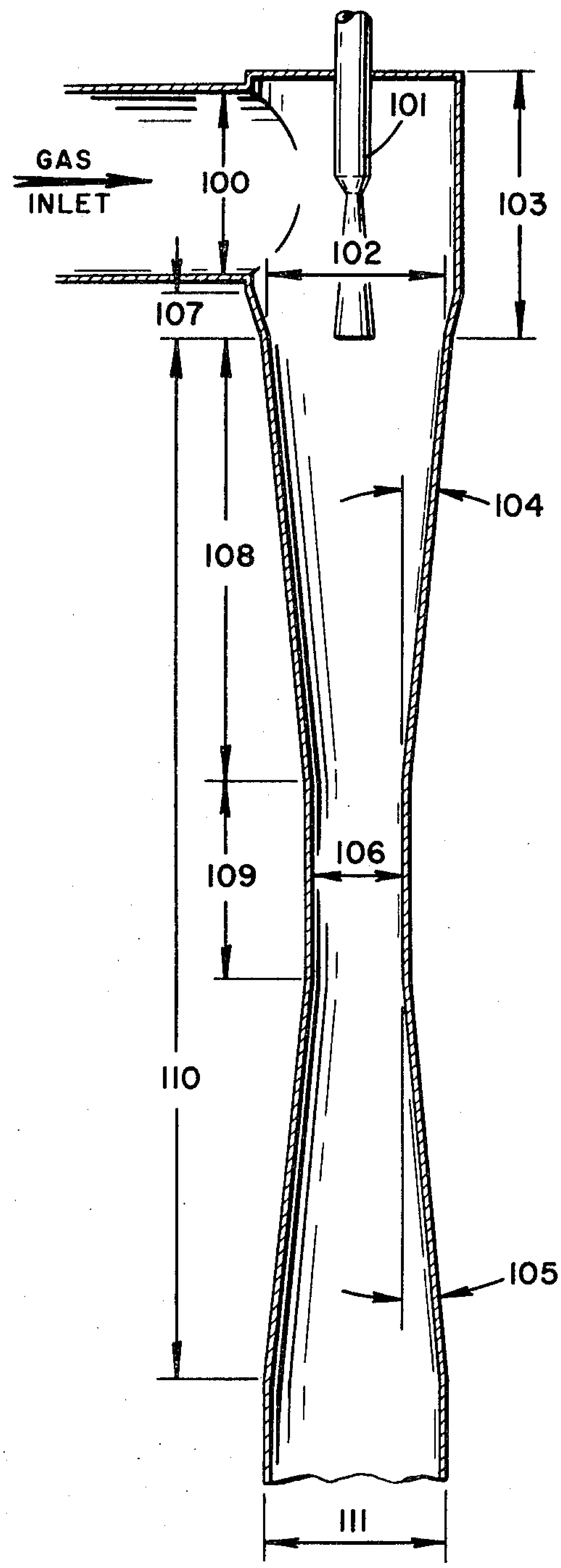

FIG. 2

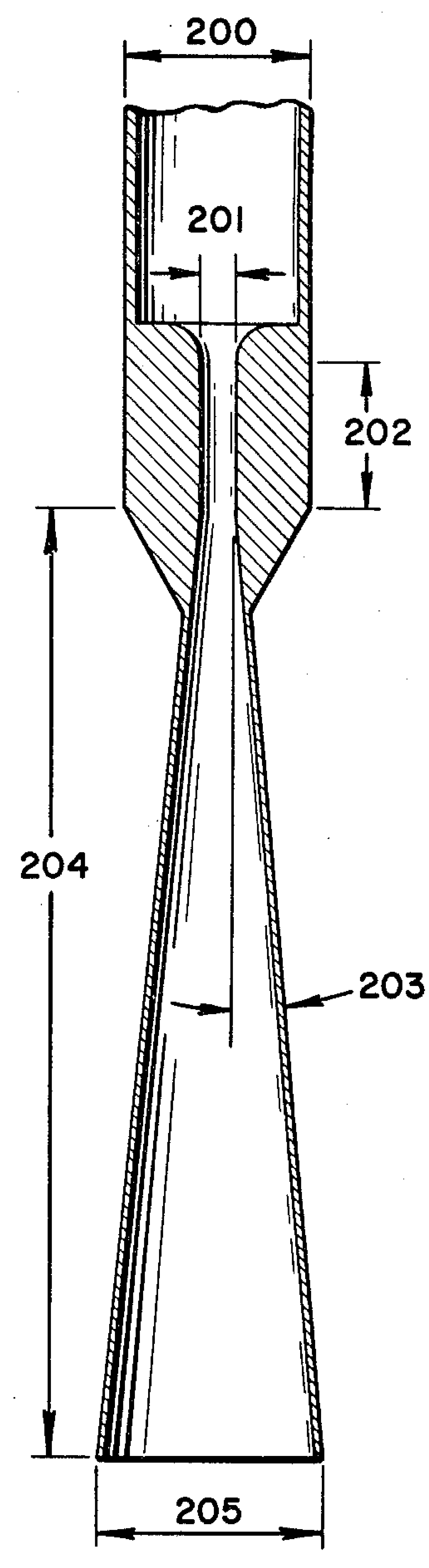

FIG. 3

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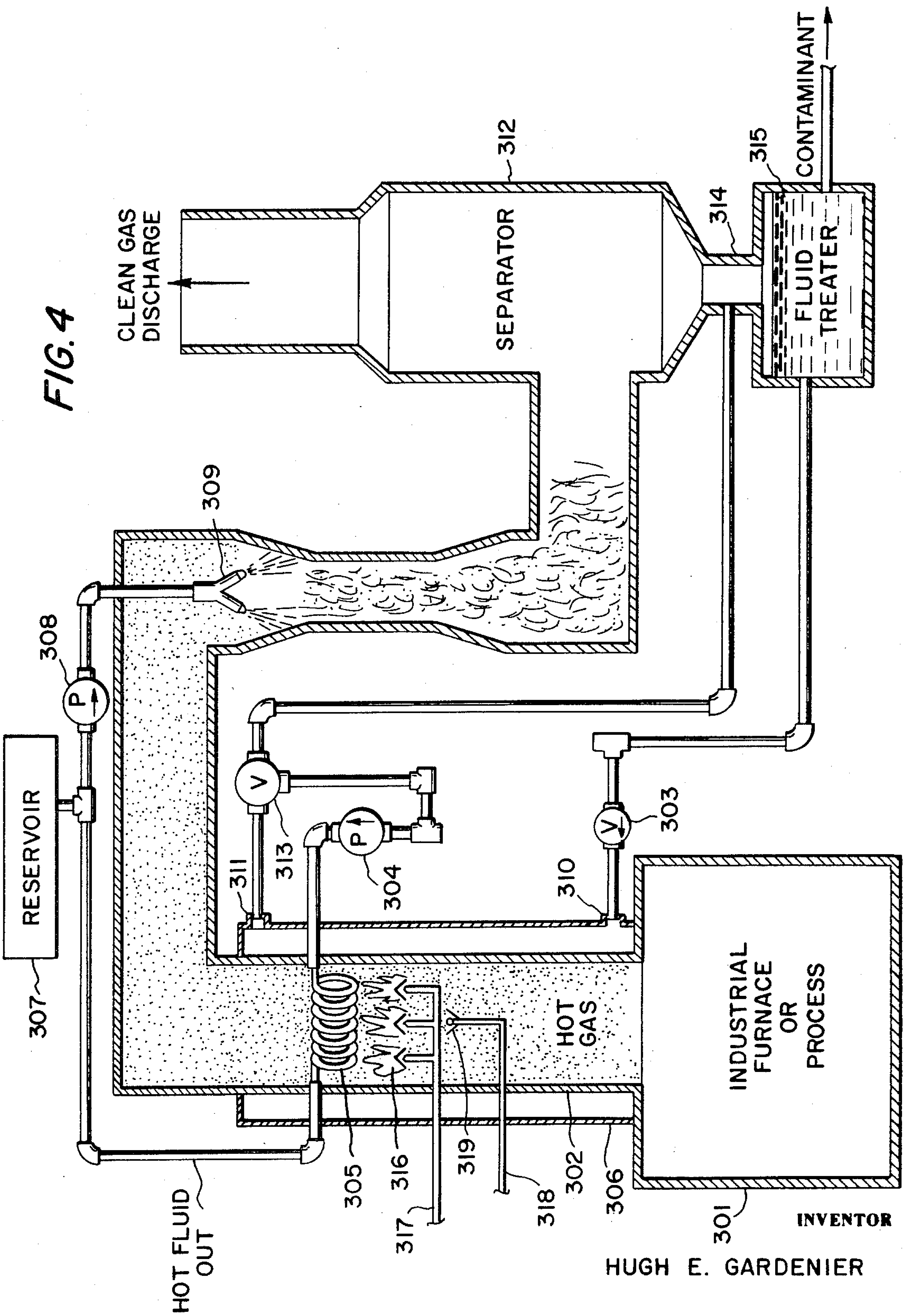
FIG. 4



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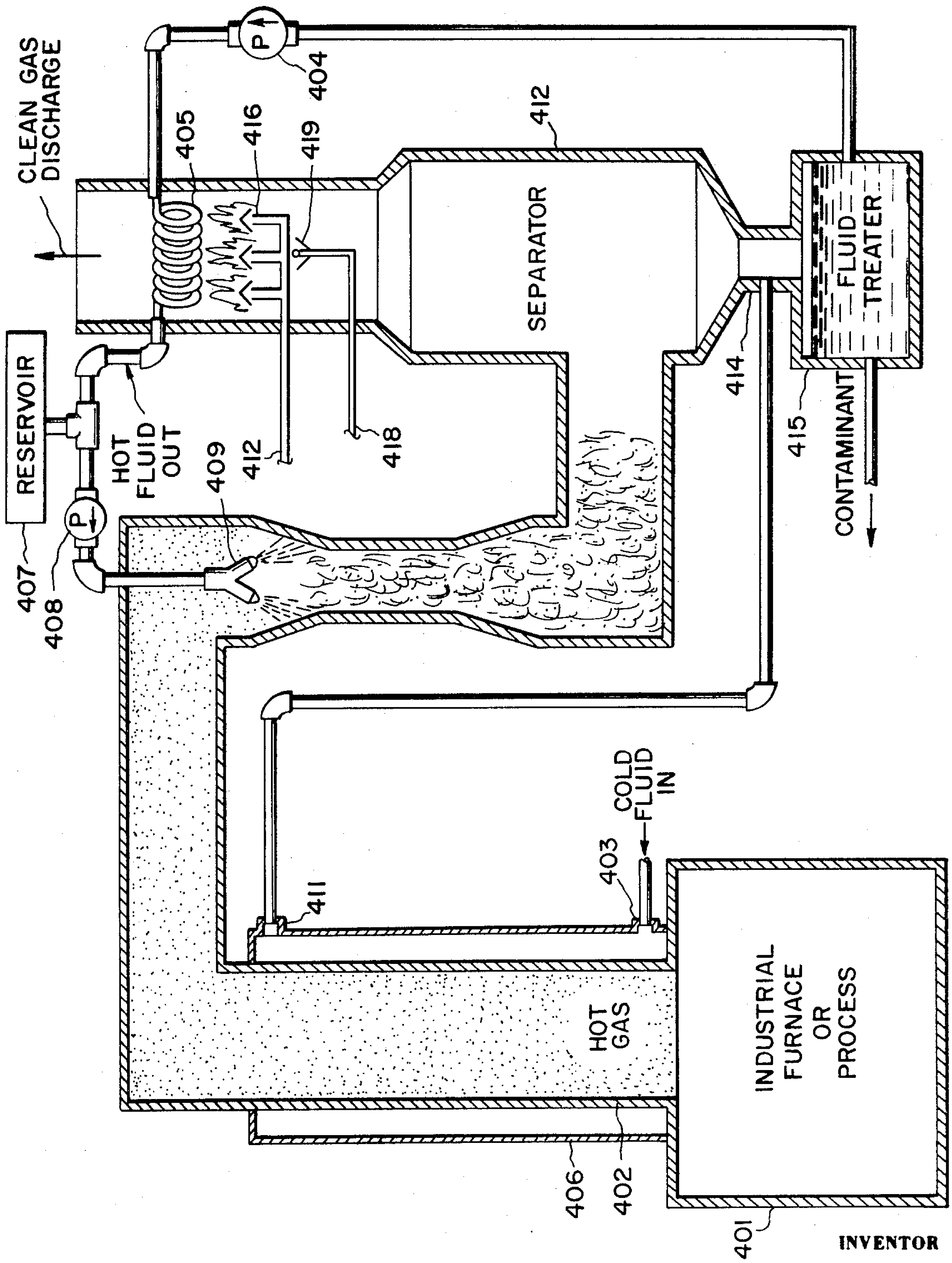

FIG. 5

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PROCESS AND APPARATUS FOR CLEANING AND PUMPING CONTAMINATED INDUSTRIAL GASES

This application is a continuation-in-part of application Ser. No. 842,635, filed July 17, 1969 and now U.S. Pat. No. 3,613,333.

This invention relates to a process and apparatus for cleaning and pumping industrial gases.

Many industrial processes require the application of heat to basic materials so that the material can be melted and combined with other substances or purified and refined. Typical of this type of process is steel production and the refining of nonferrous metallic ores. A by-product of these processes is frequently high temperature contaminated gases. For many years these industrial waste gases have been discharged in an uncontrolled manner into the atmosphere. Since this is a major identifiable source of air pollution, considerable pressure is being exerted to prevent this type of atmospheric pollution.

Currently there are two basic approaches to the problem of handling the hot contaminated industrial gases. The first process is generally referred to as the dry filter system. The basic elements of this system are ducting, fan, filter house, and conveyor system. The basic problem with equipment of this type is the temperature limitation of the filter elements. In most instances, the gas temperature must be cooled below approximately 500°F before it is filtered. The cooling can be accomplished by drawing atmospheric air into the ducting and mixing it with the contaminated industrial gas. This additional air required for cooling increases the size of the fan and motor necessary to draw the gases through the ducting and into the filter house. The fans employed are generally placed directly in the ducting and thus are subject to corrosion by the hot gas stream resulting in high maintenance costs. Furthermore fans of this type generally require up to about 4,000 horsepower for operation, thereby representing a major portion of the operating costs of the system. The system works satisfactorily; however, as mentioned above, the installation cost is high and the maintenance of the fan and filters is costly.

The second basic type of cleaning system is referred to as the wet scrubber process. The basic elements of this system are gas ducting, venturi, in-stream fan, water separator, and water filter system. With this type of equipment, the hot gases are removed from the process through the gas ducting and are passed through a venturi to increase the velocity thereof. At this point, water is injected into the gas stream and the contaminants are captured in the water particles. The mixture is then passed through a fan into a water separator where the clean gases discharge to atmosphere and the contaminated water is discharge to a water cleaning system. Equipment of this type works satisfactorily; however, the installation cost is high and the operating and maintenance costs are also very high.

It is therefore an object of this invention to provide a process and apparatus for efficiently removing contaminants from industrial gases such that the gases can be discharged into the atmosphere without accompanying air pollution.

A further object of this invention is to accomplish the above object with equipment of low installation cost.

A still further object of this invention is to provide a process and apparatus which will substantially reduce operating costs.

A still further object of this invention is to utilize heat extracted from the industrial gases or the combustion of those gases as the primary energy source thereby decreasing cost.

A still further object is to simultaneously pump and clean the contaminated gases thereby decreasing costs.

A still further object is to provide a process and apparatus utilizing raw materials which can be effectively recovered, treated and recycled through the system thereby reducing operating cost.

Yet another object of the invention is to provide a process and apparatus for cleansing contaminated hot gases which uses the hot gases to pre-heat the cleansing liquid.

Still a further object of the invention is to provide a process and apparatus for cleansing contaminated hot gases and including means for pre-cooling the hot gases.

Another object of the invention is to provide a process and apparatus for cleansing contaminated hot gases with a liquid spray system, and including auxiliary heating means for the cleansing liquid.

Yet a further object of the invention is to provide a process and apparatus for cleansing contaminated hot gases wherein the cleansing liquid is preheated through the means of the combustible elements in the contaminated gases.

These and other objects will be apparent from the following specification and claims considered together with the accompanying drawings.

According to one aspect of this invention, a flowing hot gas containing contaminants is indirectly heat exchange with a liquid thereby raising the temperature of the liquid, the liquid is then introduced into said hot gas downstream of the point of heat exchange under conditions of elevated temperature and pressure such that at least a portion of said liquid is converted to vapor and the remainder is atomized and accelerated by the expansion accompanying said vapor formation, and the hot gas is then mixed with said vaporized and atomized liquid thereby entrapping said contaminants in said atomized liquid. According to an alternate feature of the present invention the hot gases, when they are suitably combustible, are ignited in the presence of additional oxygen (e.g. air) to provide heat to the heat exchanger through which the liquid is passed prior to being introduced directly into the hot gas downstream of the heat exchanger. In such cases an external source of ignition for the hot gases and air is provided, for example, by a pilot burner supplied by an exterior fuel source.

According to another aspect of this invention, a region of reduced pressure relative to the pressure in the source of hot gas is created by the liquid introduced into said hot gas thereby inducing the flow of said hot gas containing contaminants through ducting past said indirect heat exchange means, past the point of introduction, and into the mixing means thereby simultaneously pumping and cleaning said gas.

According to yet another aspect of this invention, after mixing said vaporized and atomized liquid with said hot gas, the thus formed mixture is passed to a separator from which said hot gas substantially free of contaminants is exhausted to the atmosphere or to further processing and the atomized liquid containing entrapped particles is discharged as a stream of liquid.

According to yet another aspect of this invention, the above discharged stream of liquid containing said contaminants is treated to remove the contaminants from at least a portion thereof and at least a portion of the thus cleaned liquid is recycled through said indirect heat exchange means.

According to yet another aspect of this invention, the mixture of vaporized and atomized liquid and hot gas is contacted with a coolant prior to passing to said separator to reduce the temperature thereof thereby condensing at least a part of the vaporized liquid.

According to yet another aspect of this invention, an apparatus is provided with which to carry out the above and further aspects comprising in part means for indirectly heat exchanging a gas flowing in ducting and a liquid, mixing means located downstream of said indirect heat exchange means, means interconnecting said indirect heat exchange means with said mixing, means for converting at least a part of the liquid to vapor and atomizing the remaining liquid and for introducing the atomized liquid into said mixing means, and means located downstream of said mixing means for separating said liquid from said hot gas.

These and other aspects of this invention will be more fully appreciated by referring to the accompanying drawings wherein:

FIG. 1 is a schematic flow diagram of one aspect of the process of the invention;

FIG. 2 is a schematic representation of one arrangement of nozzle and mixing chamber;

FIG. 3 is a schematic representation of the details of one particular nozzle;

FIG. 4 is a schematic flow diagram showing additional aspects of the process of the invention; and

FIG. 5 is a schematic flow diagram of still another aspect of the process of the invention.

Referring to FIG. 1, the industrial furnace or process 1 represents any furnace or process in which hot gas containing contaminants is produced either as a primary or secondary product. Exemplary are processes in which heat is applied to basic material which is melted and combined with other substances or purified and refined, such as process for steel production, for example, processes utilizing basic oxygen steel furnaces, blast furnaces, and electric arc steel furnaces of from about 25 to greater than 200 tons of steel capacity or foundary cupolas, or the refining and purification of nonferrous metallic ores, for example, titanium, or processes for the production of glass. The contaminants contained in the hot gases produced from the above processes are particulate materials, such as metallic particles and oxides, and also gaseous contaminants of many types.

Gas ducting 2 is provided so that the hot industrial gases may be drawn away from the furnace or processing vessel. Energy contained in these high temperature gases is transferred to a liquid heat transfer medium by means of indirect heat exchanger 5. The indirect heat exchanger can be of any commercially available configuration, the surface area of which is designed for the proper liquid temperatures at the design flow rates for each particular system as is well understood by those killed in the art. A liquid pump 4 is provided to force the liquid through indirect heat exchanger 5 at least in part from a source indicated generally as 3. The heat exchange medium can be any liquid commonly used as such and is selected from a consideration of the particular process parameters present in the system together with the properties of the liquid such as heat capacity, vapor pressure, etc. as will be well understood by those skilled from a consideration of the above and the following detailed description of the invention. For example, the liquid can be water, freon, etc.; however, because of its availability and desirable properties, the invention will hereinafter be described with reference to water as the heat exchange medium although the medium obviously need not be limited to such.

Energy contained in the high temperature gas, which, for example, can be from about 200° to 3,500°F, is transferred to the water through the indirect heat exchanger. The heated water flows from the indirect heat exchanger through transfer means 6 and is stored for later use in the reservoir 7 or delivered by a water pump 8 directly to ejector nozzle 9, one embodiment of which is shown in greater detail in FIG. 3.

Because of the relative velocity between the water droplets issuing from the nozzle and the gas contaminants, the droplets will entrap the particles carried by the gas stream. Gaseous contaminants which are soluble in the water or liquid employed will also be removed from the gas stream by mass transfer therewith thus forming a solution with the water droplets. The velocity of the droplet is controlled by the area of the nozzle exit, the dimensions of the mixing chamber, the pressure of the water upstream of the nozzle, and the amount of fluid converted to vapor, and the temperature of the water. These variables can, of course, be varied within a wide range depending upon economic considerations, such as size of the equipment and the nature and temperature of the hot gas. It has been found that the droplet velocity must be at least about 200 ft./sec greater than the velocity of the gas stream. More preferably, the velocity of the droplets is at least about 700 ft./sec greater than the velocity of the gas stream.

Because of the conditions of temperature and pressure of the water, the pressure being elevated by the combined action of pumps 4 and 8, at least a portion of the water is converted to steam as it issues from the nozzle. The expansion accompanying the formation of the steam or vapor accelerates and separates the remaining water into small droplets that are thereby propelled at high velocity. In general, it is necessary to adjust the temperature and pressure of the water in relationship to the apparatus employed such that from about 5 to about 20 weight percent of the water issuing from the nozzle is converted to vapor in order to obtain the proper droplet velocity. For most applications, it has been found adequate to convert about 15 percent of the water to vapor. Since in this relationship the temperature and pressure of the water are dependent variables, it is possible to select many sets of temperatures and pressures which will result in the required conversion of the water to vapor. In general, it has been found that water pressures of from about 50 to 700 psia and water temperatures of from about 220° to about 500°F are adequate. Of course, temperatures and pressures outside of this range may be amployed.

The temperature of the hot gas, of course, limits the temperature to which the water can be efficiently raised in indirect heat exchanger **5**. For hot gases of from about 200° to about 3,500°F, the above parameters are applicable. For hot gases in the lower temperatures of this range, higher pressures and/or smaller nozzle areas and/or smaller mixing chamber throat areas can be employed and vice versa. Furthermore, an absolute lower limit on the water temperature is generally set at 212°F since for temperatures lower than this reduced pressure is required to partially vaporize the water therefore necessitating the use of vacuum producing equipment which would substantially increase the installation and operating costs of the instant invention. It is generally desirable to operate within the higher temperatures and pressures given above since smaller equipment can be used therewith.

In general, the volume of water employed is not a critical parameter and water flow rates within the range of from about 1 to about 3,000 gal./min. are effective. It has been found, however, that the ratio of the weight of hot gas to the total weight of water employed must be controlled to some extent. For most systems, a ratio of the weight of gas to the weight of water must be within the range of from about 0.5 to about 2.5, more preferably from about 1.5 to about 2. This system operates effectively over a wide range of contaminant concentrations. Higher water flows, of course, are necessary for systems containing higher concentrations of contaminants.

The exact size and composition of the contaminant particles is not a critical parameter of the instant invention and it has been found that contaminant particles as small as **1** micron can be efficiently removed. According to the invention, greater than 90 percent of the contaminant particles can be removed; however, removal efficiencies as high as about 99.95 percent can be achieved although at some sacrifice of process economics.

From the above, it should be clear that each individual application of this process requires an engineering analysis to determine the proper water temperature, flow rate and pressure. The operating principle remains the same, however, regardless of the size and type of application.

The geometry of a typical nozzle and mixing chamber is shown in FIGS. **2** and **3**, the dimensions of which are varied depending on the volume flow of gas required, type of contaminants in the gas, and the degree of cleaning necessary. It should also be noted that the ejector nozzle can be either a single nozzle similar to the one shown in the diagram, or a cluster of several nozzles as will be obvious to those skilled in the art. The water flow created by pump **8** (FIG. **1**) passes through the ejector nozzle shown generally at **101**. The hot gas containing contaminants passes through ducting **100** after passing over indirect heat exchanger **5** (FIG. **1**). The water enters the nozzle through **200** into the throat area **202** through the expanding portion shown as **204** and the exit shown as **205**. As described above, because of the temperature and pressure of the water and the apparatus dimensions, at least a portion of the water is converted to steam by exiting through the nozzle. In the venturi-shaped mixing chamber **10** shown generally in FIG. **1** and in more detail in FIG. **2**, the mixture velocity produces pressure shock waves therein enhancing the mixing of the water droplets and the contaminated gas. In general, the requisite droplet velocity and mixing are attained in apparatus having the ratio of nozzle exit area to nozzle throat area of from about 1 to about 50 and the ratio of mixing chamber throat area **106** to nozzle throat area **201** of from about 50 to about 1,000.

The dimensions of the apparatus are in general a function of the temperature of the flowing gas stream. As previously stated, the quantity of water converted to vapor determines in part the velocity of the droplets. The velocity of the droplets due to this phenomenon is thus a function of the available thermal energy in the flowing gas stream. For higher temperatures, the water may be heat exchanged to a higher temperature, thereby causing greater conversion to vapor, all other parameters being held constant. Thus, for systems of lower thermal energy, the above area ratios are placed in the lower ranges in order to create a smaller geometry thus achieving higher velocities and vice versa.

The expansion accompanying the formation of vapor as the fluid exits from the nozzle, the venturi effect in the mixing chamber, and the pressure shock waves created therein create a region of reduced pressure in the vicinity of the nozzle relative to the pressure in the industrial furnace or process such that a pressure differential is imposed on the system causing the gas to be sucked from the furnace or process. Thus the system is further designed to impose the pressure differential required to remove the quantity of gas produced by the furnace or process within a broad general range, the control of the flow rate being more finely adjusted by the velocity of the liquid issuing from the nozzle.

Referring back to FIG. **1**, the mixture of atomized liquid, vaporized liquid, and hot gas exiting from the mixing chamber can be optionally further contacted with a coolant. The coolant may be the same or different as the liquid used as the heat exchange medium. For most applications, it is of course preferred to use the same liquid for both purposes. The contacting of the coolant with the mixture is accomplished by spraying said coolant into the ducting containing the gas for instance, through a cluster of nozzles such as shown by **11**. Any configuration of nozzles commonly used for similar purposes in the industry is acceptable. In systems employing recycle of the heat exchange medium in order to conserve operating costs, it is necessary to reduce the temperature of the mixture thereby condensing at least a portion of the vaporized liquid thereby reducing the loss of said liquid. In general, where water is employed as the heat exchange medium it is necessary to reduce the temperature of the mixture to from about 150° to about 200°F, more preferably to about 175°F. In this way it has been found that only about 10 percent of the water employed remains as vapor and is thus lost to the system.

The mixture is then passed to a commercially available water separator **12** wherein the water droplets containing the contaminants are separated from the gas stream which then may be discharged to the atmosphere through **13** or to further processing. For example, the water separator can be similar to the cycle separators manufactured by the R.P. Adams Co., The

Burgess Co., the Centrifix Corp., or the Raliegh-Austin Co.

The dirty water is removed from the separator through **14** and can be either discharged or passed to further treatment described below depending upon the economics of the process. The dirty water can be passed to a liquid treater shown at **15** wherein the contaminants can be removed from at least a portion of the water. The clean water is removed through transfer means **15**, at least a portion of which is then recycled through pump **4** through the system, makeup water being added from the source **3** as may be required. The liquid treating apparatus can be any commercially available equipment comprising, for example, a system of filters and settling basins, etc.

In still a further embodiment of the present invention, the gases discharged from the separator subsequent to being treated to remove contaminants, when they contain combustible elements, are mixed with externally supplied oxygen (e.g. air) and ignited by suitable means such as, for example, a pilot burner fueled externally. In this manner, there is provided combustion for a heat exchanger through which cleansing fluid is passed. Then the heated cleansing liquid is introduced, as described above, at a point upstream of the separator and under conditions of elevated temperatures and pressures into the hot gas stream.

In yet a further embodiment of the present invention a jacket is provided around the gas ducting which conducts gas away from the furnace, so that suitable cooling liquid, such as water, can be circulated around the ducting to quench the hot gas emerging from the furnace. If such quenching water is used as the cleansing liquid, it will be appreciated that the quenching of the hot gases also preheats the quenching liquid. The water or other liquid for this quenching jacket can be supplied from an external source and then, after it has performed its quenching function, be added to the fluid emerging from the separator. Alternatively, the fluid used for quenching can be supplied from the fluid treater from whence it is pumped to the quenching jacket and on emerging from the quenching jacket, be passed through heat exchanger tubes located in the hot gas duct or returned and added to the fluid emerging from the bottom of the separator.

Referring now to FIG. **4**, it can be seen that a quenching jacket is provided at **306** around the gas duct **302** into which cooling fluid is introduced at **310** from the fluid treater **315** through the recycling pump **303**. This fluid serves to quench the hot contaminated gas emerging from the furnace **301** and then emerges from the quenching jacket **306** at **311** where it passes to valve means **313** and in part is directed through the pump **304** to the heat exchanger **305** and then to the reservoir **307**. From the reservoir the heated fluid is pumped by the pump **308** to the ejector nozzle **309**. The heat exchanger tubes **305** are heated by the combustion at **316** of the contaminant gas emerging from the furnace and mixed with air provided externally at **317** and ignited by the pilot burner **319** which is fueled externally at **318**. Liquid from the quenching jacket which is not passed through the heat exchanger **305** is returned and added to the fluid from the separator **312** at **314**.

Referring to FIG. **5**, the treated liquid from the fluid treater **415** is pumped by means of a recycle pump **404** to the upper portion of the separator **412** and there passed through the heat exchanger **405** where the liquid is heated and passed to the reservoir **407**. From the reservoir, the heated fluid is then pumped by means of the pump **408** to the ejector nozzles **409**. Heating of the liquid in the heat exchanger **405** is effected by combustion of the discharge gas which is mixed with air at **416** from an external source **412** and ignited by a pilot burner **419**. The pilot burner is fueled externally at **418**. Quenching of the hot gases emerging from the furnace **401** is accomplished in the gas duct **402** which is surrounded by a quenching jacket **406**. Water is supplied from a suitable source to the quencher at **403** and emerges at **411** where it is passed into the stream of liquid emerging at **414** from the bottom of the separator **412**.

Other aspects of this invention will be apparent from a consideration of the following specific example which is not intended to be limiting in any manner.

EXAMPLE

In the production of steel employing an electric-arc furnace of 200 ton steel capacity, gas is discharged at about 3,000°F at a flow rate of about 130,000 cubic feet per minute. The contaminants contained in said gas include ferric oxide, dolomite, zinc, copper and other trace metallic elements. Water is employed as the heat exchange medium and the water pressure at the nozzle is 400 psia, the temperature is 358°F, and the flow rate is 440 gal/min. Referring to FIG. **1**, the gas ducting **2** is 6 feet in diameter and the heat exchanger **5** is a simple tube-type with nominal 1-inch diameter tubes. Referring to FIGS. **2** and **3**, the dimensions of the mixing chamber and the nozzle are given in the following table:

TABLE

Reference Numeral from FIGS. 2 and 3	Dimension
100	6'
103	8'6''
104	3°
105	5°
106	3'
107	1'6''
108	28'6''
109	6'
110	51'9''
111	6'
200	5''
201	1''
202	4''
203	5°
204	2'2.4''
205	5.5''

wherein ' is feet, '' is inches, and ° is degrees.

The mixture issuing from the mixing chamber is contacted with additional water spray to lower the temperature to 175°F thereby partially condensing the remaining water vapor. The mixture then flows through separator **12** wherein the clean gas is discharge through **13** and the dirty water is discharged through transfer means **14** to water treater **15**. The contaminants are removed through **17** and at least a portion of the clean treated water is recycled through **16**. The clean gas is thus discharged to the atmosphere.

As mentioned above, the water is discharged through the nozzle from a pressure of 400 psia into the mixing chamber such that the velocity of the water droplets formed thereby is 815 ft/sec. thereby creating a region of reduced pressure in the vicinity of said nozzle of 13 psia relative to the pressure existing in the electric-arc furnace of about 14.7 psia. This induced pressure differential of 1.7 psia causes the gas to flow from said furnace at the above rate of 130,000 cubic ft/min. which is thus equal to a gas velocity in the vicinity of said nozzle of 150 ft/sec. The water droplets thus travel at a velocity of 665 ft/sec. greater than the velocity of the gas contaminants thereby entrapping the contaminants carried by the gas stream such that the gas discharged to the atmosphere contains less than about 10 percent of the contaminants contained therein before treatment.

What is claimed is

1. An apparatus for drawing contaminated gases from a source and for removing contaminant particles therefrom, wherein the contaminated gases are of the type capable of supporting combustion, the apparatus comprising in combination:

ducting connected to said source for delivering said contaminated gases to a discharge region;

a source of a cleansing medium in its liquid state;

heat exchange means for heating said liquid cleansing medium;

low pressure ducting means for mixing the gases and the cleansing medium, located intermediate said source and said discharge region and forming a continuous path therewith;

delivery means for conveying the heated cleansing medium from said heat exchange means to the region of said low pressure ducting means;

nozzle means integral with said delivery means at the end thereof in the region of said low pressure ducting means, for converting a portion of the heated liquid cleansing medium into vapor and a portion of the heated liquid cleansing medium into atomized droplets, and for injecting the atomized droplets into the region of said low pressure ducting means at a high velocity, said nozzle means comprising an area of reduced pressure wherein, through temperature and pressure considerations, the heated liquid cleansing medium is converted into vapor and atomized droplets;

said low pressure ducting means and said nozzle means cooperating and being dimensioned in such a manner that the velocity of said atomized droplets exiting said nozzle means is at least 200 feet per second greater than the velocity of the hot gases, and in such a manner that a reduced pressure is developed in said low pressure ducting means of such a magnitude as to draw the hot gases from said source toward said low pressure ducting means without the provision of a fan;

pump means for driving the liquid cleansing medium from said source to said nozzle means;

separator means located downstream of said low pressure ducting means for separating the atomized droplets containing the contaminant particles from the contaminated gases;

discharge means in said discharge region for releasing cleansed gases to the atmosphere;

means for removing the cleansing medium, with the entrapped contaminant particles, from said separator means;

a combustion zone located within the boundaries of said ducting for housing said heat exchange means and for heating said liquid cleansing medium;

means for supplying sufficient oxygen to said contaminated gases in said combustion zone to support combustion of said gases; and

means for igniting said contaminated gases.

2. The apparatus of claim 1, wherein said means for igniting the contaminated gases takes the form of a pilot burner supplied by an external source of combustible gas.

3. The apparatus of claim 2, wherein said combustion zone is located between said source and said low pressure ducting.

4. The apparatus of claim 2, wherein said combustion zone is located between said low pressure ducting and said discharge region.

5. The apparatus of claim 2, wherein the contaminated gases are hot and further comprising: a cooling jacket surrounding said ducting in the region of said source of contaminated gases, said cooling jacket being provided with coolant intake and exit means for circulating a cooling liquid through said cooling jacket.

6. An apparatus for drawing hot gases from a source and for removing the contaminant particles therefrom, the apparatus comprising in combination:

ducting means connected to said source for delivering said hot gases to a discharge region;

a source of a cleansing medium in its liquid state;

heat exchange means for heating said liquid cleansing medium;

low pressure ducting means for mixing the hot gases and the cleansing medium, located intermediate said source and said discharge region and forming a continuous path therewith;

a cooling jacket surrounding said ducting in the region of said source of hot gases, said cooling jacket being provided with coolant intake and exit means for circulating cooling liquid therethrough;

delivery means for conveying the heated cleansing medium from said heat exchange means to the region of said low pressure ducting means;

nozzle means integral with said delivery means at the end thereof in the region of said low pressure ducting means, for converting a portion of the heated liquid cleansing medium into vapor and a portion of the heated liquid cleansing medium into atomized droplets, and for injecting the atomized droplets into the region of said low pressure ducting means at a high velocity, said nozzle means comprising an area of reduced pressure wherein, through temperature and pressure considerations, the heated liquid cleansing medium is converted into vapor and atomized droplets;

said low pressure ducting means and said nozzle means cooperating and being dimensioned in such a manner that the velocity of said atomized droplets exiting said nozzle means is at least 200 feet per second greater than the velocity of the hot gases, and in such a manner that a reduced pressure is developed in said low pressure ducting means of such a magnitude as to draw the hot gases from said source towards said low pressure ducting means without the provision of a fan;

pump means for driving the liquid cleansing medium from said source to said nozzle means;

separator means located downstream of said low pressure ducting means for separating the atomized droplets containing the contaminant particles from the hot gases;

discharge means in said discharge region for releasing cleansed hot gases to the atmosphere; and

means for removing the cleansing medium, with the entrapped contaminant particles, from said separator means.

7. The apparatus of claim 6, wherein said cooling liquid, once having been circulated through said cooling jacket, is used as said heated cleansing medium.

8. The apparatus of claim 7, and further comprising auxiliary heating means for heating said cooling liquid before said cooling liquid reaches said nozzle means.

9. The apparatus of claim 8, wherein said heat exchange means is located in said ducting and serves to indirectly heat exchange said hot gases in said ducting with the liquid cleansing medium.

10. A method for drawing contaminated gases from a source through ducting and for removing contaminant particles therefrom, wherein the contaminated gases are of the type capable of supporting combustion, the method comprising the steps of:

heating a liquid cleansing medium in said ducting by the combustion of said contaminated gases;

introducing the heated cleansing medium to nozzle means under conditions of temperature and pressure such that a portion of the heated liquid cleansing medium is converted into vapor, a portion of the heated liquid cleansing medium is converted into atomized droplets, and the atomized droplets are accelerated by the expansion accompanying the vapor formation at an exit velocity at least 200 feet per second greater than the velocity of the contaminated gases;

mixing the accelerated atomized droplets with the contaminated gases in a mixing chamber located downstream of the nozzle means, thereby entrapping the contaminant particles in the accelerated atomized droplets and thereby developing a region of reduced pressure of such a magnitude as to draw the contaminated gases from the source toward the mixing chamber without the provision of a fan;

separating the atomized droplets containing the contaminant particles from the contaminated gases, thereby producing a stream of substantially contaminant-free gas; and

discharging the substantially contaminant-free gas to the atmosphere.

11. The method of claim 10, wherein the combustion of the contaminated gases is maintained by a pilot burner supplied by an external source of combustible gas.

12. The method of claim 10, wherein the combustion of said contaminated gases takes place intermediate the source of contaminated gases and the mixing chamber.

13. The method of claim 10, wherein the combustion of said contaminated gases takes place intermediate the mixing chamber and the region of gas discharge.

14. The method of claim 10, wherein the contaminated gases are hot, and further comprising the step of cooling the hot contaminated gases with a cooling jacket surrounding said ducting in the region of said source.

15. A method for drawing hot contaminated gases from a source through ducting and for removing contaminant particles therefrom, the method comprising the steps of:

heating a liquid cleansing medium;

introducing the heated cleansing medium to nozzle means under conditions of temperature and pressure such that a portion of the heated liquid cleansing medium is converted into vapor, a portion of the heated liquid cleansing medium is converted into atomized droplets, and the atomized droplets are accelerated by the expansion accompanying the vapor formation at an exit velocity at least 200 feet per second greater than the velocity of the hot contaminated gases;

mixing the accelerated atomized droplets with the hot contaminated gases in a mixing chamber located downstream of the nozzle means, thereby entrapping the contaminated particles in the accelerated atomized droplets and thereby developing a region of reduced pressure of such a magnitude as to draw the hot contaminated gases from the source toward the mixing chamber without the provision of a fan;

cooling the hot contaminated gases by means of a cooling jacket surrounding said ducting in the region of said source;

separating the atomized droplets containing the contaminant particles from the hot contaminated gases, thereby producing a stream of substantially contaminant-free gas; and

discharging the substantially contaminant-free gas to the atmosphere.

16. The method of claim 15 and further comprising the step of using said cooling liquid, once having been circulated through said cooling jacket, as said heated cleansing medium.

17. The method of claim 16, and further comprising the step of further heating the cooling liquid by an auxiliary heating means before said cooling liquid reaches said nozzle means.

18. The method of claim 17, and further comprising the step of indirectly heat exchanging said hot gases in said ducting with the liquid cleansing medium.

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