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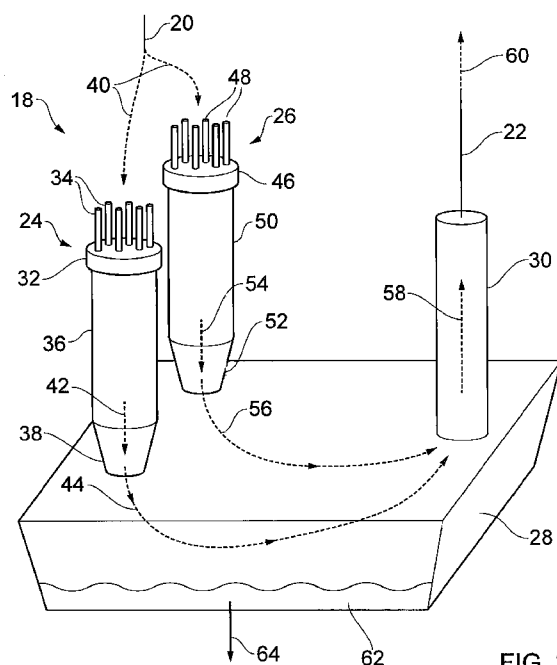


FIG. 2

(57) Abstract: An abatement system for abating process gas received from a process chamber, the abatement system comprising: a plurality of burner modules (24, 26), each burner module (24, 26) comprising a respective burner (36, 50) for receiving the process gas and combusting the process gas in oxygen, and a common scrubber (30) configured to receive combusted process gas from each of the plurality of burners (36, 50), and to remove one or more substances from the received combusted process gas.

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GAS ABATEMENT APPARATUS

FIELD OF INVENTION

The present invention relates to gas abatement, and in particular to
5 apparatuses used in the abatement of gases exhausted from a process tool,
such as a process tool used in the semiconductor manufacturing industry.

BACKGROUND

Vacuum pumping and abatement systems are used in varied and
10 different technological fields, for example semiconductor fabrication. Typically,
in said systems, vacuum pumping equipment is used to pump gas (e.g. gas
from an industrial process) out of a particular location, and abatement
equipment is used to abate (e.g. destroy or dispose of) undesirable substances
which have been produced.

15 The abatement equipment typically comprises a burner configured to
receive process gas at a plurality of nozzles, and to remove the undesirable
substances therefrom by burning the process gas in a fuel and oxygen mixture.
The abatement equipment may further comprise a washer, for example a wet
scrubber, downstream of the burner to remove particulate matter and water-
20 soluble substances, and to treat water-reactive gases within the combustion
products produced by the burner.

SUMMARY OF THE INVENTION

The present inventors have realised that it is desirable to increase
25 capacity of the abatement equipment, thereby to allow for greater volumes of
process gas to be abated in a given time period.

The present inventors have further realised that increasing the capacity
of the abatement equipment by increasing the number of nozzles at an inlet of
the abatement equipment and also increasing the size of a burner of the
30 abatement system tends to lead to undesirable and/or unpredictable changes in

the behaviour and/or performance of the burner. The present inventors have realised that this may lead to difficulties in predicting the by-products of the combustion of the process gas, which may lead to difficulties in implementing effective cleaning of the combusted gas.

5 The present inventors have further realised that capacity of the abatement equipment may be increased while at the same time maintaining the effectiveness of the abatement process by implementing, in parallel, multiple (e.g. relatively smaller) burners having known performance characteristics, as opposed to increasing the size of a burner. Each of the multiple burners may
10 have a predetermined, known number of inlet nozzles.

 In an aspect, there is provided an abatement system for abating process gas received from a process chamber. The abatement system comprises: a plurality of burner modules, each burner module comprising a respective burner for receiving the process gas and combusting the process gas in oxygen, and a
15 respective cooler coupled to the burner of that burner module, each cooler being configured to cool the combusted process gas output by the burner to which that cooler is coupled; and a common scrubber configured to receive combusted and cooled process gas from each of the plurality of burner modules, and to remove one or more substances from the received combusted
20 process gas. Advantageously, the respective coolers cool the combusted process gas which tends to improve the effectiveness of the common scrubber, and tends to reduce corrosion of or damage to downstream components (such as the common scrubber) by the combusted process gas. Furthermore, the cooling of combusted process gas tends to facilitate handling (e.g. treatment,
25 collection, etc.) of products (e.g. solid, liquid, and/or gas products) output by the burner modules and/or the common scrubber. Advantageously, the cooling of the combusted gas by the respective coolers tends to occur in a short (e.g. vertical) distance.

 The abatement system may further comprise a tank arranged to collect
30 liquid output by the plurality of burner modules and/or the common scrubber. The tank may be coupled between the plurality of burner modules and the common scrubber. The tank may comprise (e.g. be made of) a plastic. In other words, the walls of the tank may be a plastic. The plastic tank tends to be

resistant to corrosion by the (e.g. acidic) liquid output by the plurality of burner modules and/or the common scrubber. Use of a plastic tank tends to be facilitated or enabled by using the coolers to cool the combusted process gas to a temperature at which the plastic material is not damaged. The plastic tank
5 tends to be more resistant to failure compared to tanks of other materials, such as metal e.g. stainless steel.

There may be, for example, exactly one common scrubber, exactly two common scrubbers, exactly three common scrubbers, or exactly four common scrubbers.

10 At least one of the coolers may be a quench.

Each of the burner modules may comprise a respective plurality of nozzles arranged to receive the process gas and to introduce the received process gas into the burner of that burner module.

The burner modules may be substantially identical.

15 The common scrubber may be a scrubber selected from the group of scrubbers consisting of: wet scrubbers, dry scrubbers, absorbers, adsorbers, baffle spray scrubbers, ejector venturi scrubbers, liquid-to-gas ratio scrubbers, mechanically aided scrubbers, spray towers, spray nozzles, strippers, dry Electro-Static Precipitators, wet Electro-Static Precipitators and venturi
20 scrubbers. Preferably, the common scrubber is a wet scrubber.

The burner modules may be configured to operate in parallel with each other.

The burner modules may be configured to operate independently from each other. This may be such that one of the plurality of burner modules may be
25 in an "on" state while another of the plurality of burner modules is in an "off" state. This tends to allow for one or more combustor stacks to be serviced while still running others.

The abatement system may comprise exactly two burner modules. The abatement system may comprise exactly one scrubber.

30 In a further aspect, there is provided a vacuum pumping and abatement system for evacuating process gas from a process chamber and abating the

process gas. The system comprises a vacuum pumping system for evacuating process gas from the process chamber, and an abatement system for abating the process gas evacuated from the process chamber. The abatement system is in accordance with any preceding aspect.

5 In a further aspect, there is provided a method for abating process gas received from a process chamber. The method comprises receiving, by each of a plurality of burner modules, the process gas, each burner module comprising a respective burner and a respective cooler coupled to the respective burner; combusting, by the burners, the process gas in oxygen; cooling, by the coolers,
10 the combusted process gas; receiving, by a common scrubber, combusted and cooled process gas from each of the plurality of burners; and removing, by the common scrubber, one or more substances from the received combusted process gas.

 In a further aspect, there is provided an abatement system for abating
15 process gas received from a process chamber, the abatement system comprising: a plurality of burner modules, each burner module comprising a respective burner for receiving the process gas and combusting the process gas in oxygen, and one or more common scrubbers, each of the one or more common scrubbers being arranged to receive combusted process gas from
20 each of the plurality of burners, and to remove one or more substances from the received combusted process gas. The burner modules are configured to operate independently from each other. This tends to allow for one or more of the plurality of burner modules to be in an “on” state (i.e. combusting process gas) while one or more other of the plurality of burner modules is in an “off”
25 state (i.e. not combusting process gas). Thus, one or more of the burner modules (or combustor stacks) may be switched off, serviced, undergo maintenance, be repaired, etc. while others of the burner modules remain switched on, i.e. combusting the process gas.

 In a further aspect, there is provided an abatement system for abating
30 process gas received from a process chamber, the abatement system comprising: a plurality of burner modules, each burner module comprising a respective burner for receiving the process gas and combusting the process gas in oxygen, and one or more common scrubbers, each of the one or more

common scrubbers being arranged to receive combusted process gas from each of the plurality of burners, and to remove one or more substances from the received combusted process gas. There may be, for example, exactly one common scrubber, exactly two common scrubbers, exactly three common scrubbers, or exactly four common scrubbers.

In any preceding aspect, the abatement system may further comprise a plurality of coolers, each cooler coupled to a respective one of the plurality of burners, each cooler being configured to cool the combusted process gas output by the burner to which that cooler is coupled and to output cooled combusted process gas for use by the common scrubber.

Each of the burner modules may comprise a respective plurality of nozzles arranged to receive the process gas and to introduce the received process gas into the burner of that burner module.

The burner modules may be substantially identical.

Each of the one or more common scrubbers may be a scrubber selected from the group of scrubbers consisting of: wet scrubbers, dry scrubbers, absorbers, adsorbers, baffle spray scrubbers, ejector venturi scrubbers, liquid-to-gas ratio scrubbers, mechanically aided scrubbers, spray towers, spray nozzles, strippers, dry Electro-Static Precipitators, wet Electro-Static Precipitators and venturi scrubbers.

The abatement system may further comprise a tank arranged to collect liquid output by the plurality of burner modules and/or the one or more common scrubbers.

The tank may be coupled between the plurality of burner modules and the one or more common scrubbers.

The tank may comprise a plastic.

The burner modules may be configured to operate in parallel with each other.

The burner modules may be configured to operate independently from each other such that one of the plurality of burner modules may be in an "on" state while another of the plurality of burner modules is in an "off" state.

The abatement system may comprise exactly two burner modules.

The abatement system may comprise exactly one scrubber.

In a further aspect, there is provided a vacuum pumping and abatement system for evacuating process gas from a process chamber and abating the process gas, the system comprising: a vacuum pumping system for evacuating process gas from the process chamber, and an abatement system for abating the process gas evacuated from the process chamber; wherein the abatement system is in accordance with the first aspect.

In a further aspect, there is provided a method for abating process gas received from a process chamber, the method comprising: receiving, by each of a plurality of burner modules, the process gas, each burner module comprising a respective burner; combusting, by the burners, the process gas in oxygen; receiving, by one or more common scrubbers, combusted process gas from each of the plurality of burners; and removing, by the one or more common scrubbers, one or more substances from the received combusted process gas.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic illustration (not to scale) showing a vacuum pumping and abatement system; and

Figure 2 is a schematic illustration (not to scale) showing a perspective view of the abatement apparatus of the vacuum pumping and abatement system.

DETAILED DESCRIPTION

Figure 1 is a schematic illustration (not to scale) showing a vacuum pumping and abatement system 10 for evacuating process gas from a process chamber 12 and removing noxious substances from the process gas.

The processing of products is performed in the process chamber 12 in the presence of a process gas, for example, processing of silicon wafers, such as by dielectric etching or flat panel etching. Typically, noxious substances are

exhausted from the process chamber 12 in the process gas during or after processing. These noxious substances may include, but are not limited to, CF₄, C₂F₆, NF₃, SF₆, SiF₄, SiCl₄, and/or Cl₂.

The system 10 comprises a vacuum pump 14 configured to pump the process gas from the process chamber 12 via a first fluid connection 16, commonly referred to as a "foreline". In this embodiment, the vacuum pump 14 comprises one or more dry vacuum pumps (i.e. a vacuum pump which operates without lubrication, or oil, along the gas flow path through the pump).

In some embodiments, dry nitrogen is used to purge the vacuum pump 14 and dilute potentially corrosive gases. In some embodiments, air can be used to purge the vacuum pump 14. Preferably, one or both of oil and moisture are removed from the purge gas (i.e. the dry nitrogen or the air) prior to introduction to the vacuum pump 14. It will be appreciated that instead of dry nitrogen or air, other gases may be used to purge the vacuum pump 14.

The system 10 further comprises an abatement apparatus 18 fluidly connected to the vacuum pump 14 via a second fluid connection 20. The abatement apparatus 18 is described in more detail later below with reference to Figure 2. The abatement apparatus 18 is configured to remove the noxious substances from the process gas received from the vacuum pump 14, and to output an exhaust gas via a third fluid connection 22. Preferably, the abatement apparatus 18 is configured to convert a component of the received process gas into a different compound or compounds.

The abatement apparatus 18 may output the exhaust gas via the third fluid connection 20 to, for example, the environment, or to other gas processing and/or storage apparatuses (not shown in the Figures).

Preferably, gas pressures within each of the fluid connections 16, 20, 22 are sub-atmospheric. This advantageously tends to provide that, in the event of an inadvertent leak, gases inside those fluid connections 16, 20, 22 do not flow out of those fluid connections 16, 20, 22, and instead air tends to be drawn into those fluid connections 16, 20, 22.

Figure 2 is a schematic illustration (not to scale) showing the abatement apparatus 18.

In this embodiment, the abatement apparatus 18 comprises a first burner module 24, a second burner module 26, a drainage tank 28, and a washer (i.e. a scrubber) 30.

The first burner module 24 comprises a head 32 including a plurality of
5 first nozzles 34, a first burner (or combustor) 36, and a first quench 38.

As shown in Figure 2, there may be six first nozzles 34. The first nozzles 34 are coupled to the second fluid connection 20 such that, in operation, the first nozzles 34 receive a respective portion of the process gas, as indicated in Figure 2 by a dotted arrow and the reference numeral 40. The first nozzles 34
10 are inputs of the first burner module 24. The first nozzles 34 are further coupled to the first burner 36 such that, in operation, the process gas is injected by the first nozzles 34 into the first burner 36.

The first burner 36 is configured to receive the process gas from the first nozzles 34. The first burner 36 is further configured to burn, or combust, the
15 received process gas, for example in a fuel and oxygen mixture. Fuel (e.g. natural gas) may be injected into the first burner 36 at a fuel input (not shown). In some embodiments, pure oxygen is introduced to the first burner 36 to enable or facilitate combustion of the process gas. Preferably, a pressure within the first burner 36 is sub-atmospheric. This advantageously tends to provide
20 that, in the event of an inadvertent leak, gases inside the first burner 36 are not expelled from the first burner 36 to the environment, and instead air tends to be drawn into the first burner 36.

The first burner 36 is further coupled to the first quench 38 such that, in operation, the combusted process gas from the first burner 36 is received by the
25 first quench 38 as indicated in Figure 2 by a dotted arrow and the reference numeral 42.

The first quench 38 is configured to cool the combusted process gas from a relatively high temperature (for example, about 800°C-1200°C, e.g. about 1000°C) to a relatively low temperature (for example, about 50°C-100°C,
30 e.g. about 60°C). More specifically, the first quench 38 sprays water, for example as a fine mist, across the stream of combusted process gas flowing therethrough, thereby to evaporatively cool that gas stream.

The first quench 38 is further coupled to the drainage tank 28, at or proximate to a first end of the drainage tank 28, such that, in operation, the cooled gas stream is output from the first quench 38 and into the drainage tank 28 as indicated in Figure 2 by a dotted arrow and the reference numeral 44.

5 In this embodiment, the second burner module 26 is substantially identical to the first burner module 24. In particular, the second burner module 26 comprises a head 46 including a plurality of second nozzles 48, a second burner (or combustor) 50, and a second quench 52.

As shown in Figure 2, there may be six second nozzles 48. The second
10 nozzles 48 are coupled to the second fluid connection 20 such that, in operation, the second nozzles 48 receive a respective portion of the process gas, as indicated in Figure 2 by a dotted arrow and the reference numeral 40. The second nozzles 48 are inputs of the second burner module 26. The second nozzles 48 are further coupled to the second burner 50 such that, in operation,
15 the process gas is injected by the second nozzles 48 into the second burner 50.

The second burner 50 is configured to receive the process gas from the second nozzles 48. The second burner 50 is further configured to burn, or combust, the received process gas, for example in a fuel and oxygen mixture. Fuel (e.g. natural gas) may be injected into the second burner 50 at a fuel input
20 (not shown). In some embodiments, pure oxygen is introduced to the second burner 50 to enable or facilitate combustion of the process gas. Preferably, a pressure within the second burner 50 is sub-atmospheric. This advantageously tends to provide that, in the event of an inadvertent leak, gases inside the second burner 50 are not expelled from the second burner 50 to the
25 environment, and instead air tends to be drawn into the second burner 50.

The second burner 50 is further coupled to the second quench 52 such that, in operation, the combusted process gas from the second burner 50 is received by the second quench 52 as indicated in Figure 2 by a dotted arrow and the reference numeral 54.

30 The second quench 52 is configured to cool the combusted process gas from a relatively high temperature (for example, about 800°C-1200°C, e.g. about 1000°C) to a relatively low temperature (for example, about 50°C-100°C,

e.g. about 60°C). More specifically, the second quench 52 sprays water, for example as a fine mist, across the stream of combusted process gas flowing therethrough, thereby to evaporatively cool that gas stream.

The second quench 52 is further coupled to the drainage tank 28, at or proximate to the first end of the drainage tank 28, such that, in operation, the cooled gas stream is output from the second quench 52 and into the drainage tank 28 as indicated in Figure 2 by a dotted arrow and the reference numeral 56.

The drainage tank 28 is a plastic tank, for example Flame Retardant Poly Propylene (FRPP) or Chlorinated Polyvinyl Chloride (CPVC).

The first and second burner modules 24, 26 are coupled to an upper surface of the drainage tank 28 at the first end of the drainage tank 28. The first and second burner modules 24, 26 are coupled to the drainage tank 28 such that the first and second burner modules 24, 26 are adjacent and spaced-apart. The first and second burner modules 24, 26 are coupled to the drainage tank 28 via respective hermetic seals to prevent or oppose gas leaks.

The washer 30 is coupled to the upper surface of the drainage tank 28 at a second end of the drainage tank 28, the second end of the drainage tank 28 being opposite to the first end of the drainage tank 28. The washer 30 is coupled to the drainage tank 28 via a hermetic seal to prevent or oppose gas leaks.

In operation, evaporatively cooled gas streams flow from the quenches 38, 52 of the burner modules 24, 26, through the drainage tank 28, and into the washer 30. This flow of gas is indicated in Figure 2 by dotted arrows and the reference numerals 44 and 56. Thus the washer 30 receives cooled, combusted process gas. This flow 44, 56 of gas may be caused by, for example, the vacuum pump 14 forcing gas through the abatement apparatus 18 and/or by a further pump (not shown) downstream of the abatement apparatus 18 which draws gas through the abatement apparatus 18.

The washer 30 is configured to remove certain substances from a gas stream flowing through it. The washer 30 may be, for example, a wet scrubber configured to introduce a scrubbing liquid, for example water, into the gas

stream flowing through the washer 30. For example, the washer 30 may spray the gas stream with the scrubbing liquid, or may force the gas stream through a reservoir of the scrubbing liquid, or may implement some other contact method.

In addition to being coupled to the upper surface of the drainage tank 28, the washer 30 is further coupled to the third fluid connection 22 at an opposite end of the washer 30 to the end of the washer 30 that is coupled to the drainage tank 28.

In operation, the washer 30 receives the cooled, combusted process gas 44, 56 from the drainage tank 28. That gas flows through the washer 30, as indicated in Figure 2 by a dotted arrow and the reference numeral 58, whereby it is cleaned (i.e. scrubbed) by operation of the washer 30. The cleaned gas stream is output from the washer 30 to the third fluid connection 22, whereby the cleaned gas stream exits the abatement apparatus 18, as indicated in Figure 2 by a dotted arrow and the reference numeral 60.

In this embodiment, operation of the washer 30 removes solid particulate matter (e.g. sand, dust, ash, dirt, or other particles) from the cooled, combusted process gas as that gas flows through the washer 30. For example, solid particulate matter may be captured in droplets of the scrubbing liquid. These droplets of the scrubbing liquid fall into the drainage tank 28 where they are collected in liquid pool 62.

In this embodiment, operation of the washer 30 removes certain gaseous substances from the cooled, combusted process gas as that gas flows through the washer 30. For example, water-soluble gaseous substances within the gas stream tend to be absorbed or dissolved in the scrubbing liquid that is introduced to the gas stream. These droplets of the scrubbing liquid fall into the drainage tank 28 where they are collected in liquid pool 62.

The drainage tank 28 may also collect, in the liquid pool 62, liquid output by the quenches 38, 52.

Operation of the washer 30 may further cool the gas stream flowing therethrough.

In some embodiments, this removal of gaseous water-soluble substances from the gas stream means that the liquid 62 collected in the

drainage tank 28 is acidic. For example, the liquid 62 may comprise hydrofluoric acid. Advantageously, the plastic drainage tank 28 tends to be resistant to corrosion or dissolving by the acidic liquid 62.

5 The cleaned gas stream 60 that exits the washer 30 may include non-water soluble by-products of the process performed in the process chamber 12 and the combustion reaction performed in the burners 36, 50.

In this embodiment, the drainage tank 28 comprises an outlet 64 via which material collected in the drainage tank 28, such as the liquid 62 and solid matter, may be removed from the drainage tank 28 (e.g. periodically).
10 Preferably, the drainage tank 28 comprises a sensor (not shown) configured to measure the pH level of the liquid 62 in the drainage tank 28. Preferably, the drainage tank 28 comprises an inlet (not shown) via which water or another fluid (e.g. an alkaline liquid) may be introduced into the drainage tank 28 thereby to maintain the pH level of the liquid 62 at a predefined threshold level.

15 Thus, an abatement apparatus is provided.

Advantageously, the above described abatement apparatus tends to have an increased number of inlet nozzles compared to conventional abatement apparatuses. Thus, capacity of the abatement apparatus tends to be increased. Thus, a greater volume of process gas may be abated in a given
20 time period.

Conventionally, increasing the number of inlet nozzles tends to necessitate a need for a larger burner to combust the increased volume of process gas. Nozzle performance tends to be affected by the size of the burner. For example, by increasing the size of the burner coupled to the nozzles, nozzle
25 behaviour may be affected in a detrimental way, or in a way that is difficult to predict. This tends to mean that it is difficult to characterise the combustion reaction that occurs in the larger burner, meaning that the products of combustion are difficult or impossible to predict. This may lead to less effective treatment (e.g. cleaning) of combusted process gases.

30 Advantageously, the above-described abatement apparatus tends to alleviate or overcome this issue by implementing multiple separate burner modules which may operate in parallel and are coupled to a common drainage

tank and washer. Each of these multiple burners has a predefined, known number of inlet nozzles, e.g. six nozzles. Also, each of these multiple burners has known and predictable performance characteristics and behaviour. In this way, the likelihood of a nozzle being overloaded tends to be reduced and the
5 respective combustion reaction occurring in each burner tends to be predictable. Thus, the by-products of burning the process gas tend to be readily predictable and effective cleaning can more easily be implemented.

Advantageously, cooling of the combusted process gas tends to occur in a short vertical distance. Prior to the cooling, there may be a 'weir', which
10 provides an extended hot zone below the actual burners. This tends to increase residence time at high temperature, and therefore reaction efficiency, whilst protecting the outer wall of the reaction chamber.

The above described abatement apparatus may be referred to as a "paired" abatement apparatus.

15 In the above embodiments, the system comprises a single process chamber from which process gases are pumped and abated. However, in other embodiments, the system may include multiple different process chambers from which process gases are pumped and abated. In some embodiments, substantially identical processes may be carried out in the multiple different
20 process chambers. In some embodiments, different processes may be carried out in different process chambers. Process gases from the multiple different process chambers may be the same or different process gases. Process gases may be exhausted from the multiple different process chambers at the same or different rates.

25 In the above embodiments, the system comprises a single vacuum pump. However, in other embodiments, the system comprises multiple vacuum pumps. In the above embodiments, the vacuum pump is upstream of the abatement apparatus. However, in other embodiments, one or more of the vacuum pumps is located downstream of the abatement apparatus.

30 In the above embodiments, the vacuum pump is a dry vacuum pump. However, in other embodiments, one or more of the vacuum pumps is a different type of pump, for example a liquid ring pump.

In the above embodiments, the abatement apparatus comprises two different burner modules. However, in other embodiments, the abatement apparatus comprises a different number of burner modules. In some embodiments, the abatement apparatus comprises more than two burner
5 modules, e.g. 3, 4, 5, 6, 7, 8, 9, or 10 burner modules.

In the above embodiments, the burner modules of the abatement apparatus operate in parallel. However, in other embodiments, one or more of the burner modules may be switched off (or operate at a reduced rate or capacity) while one or more of the other burner modules is switched on.

10 In the above embodiments, the burner modules each comprise six inlet nozzles. However, in other embodiments, one or more of the burner modules comprises a different number of inlet nozzles. In some embodiments, one or more of the burner modules comprises less than six nozzles, i.e. 1, 2, 3, 4, or 5 nozzles. In some embodiments, one or more of the burner modules comprises
15 more than six nozzles, e.g. 7, 8, 9, 10, 11, 12, 13, 14, or 15 nozzles. Preferably, each burner module comprises the same number of inlet nozzles as each of the other burner modules.

In the above embodiments, the washer is a wet scrubber. However, in other embodiments, a different type of device for removing substances from the
20 combusted process gas may be used instead of or in addition to the washer. In other words, a different type of scrubber, other than a wet scrubber may be implemented. Examples of different types of scrubber that may be used include, but are not limited to, wet scrubbers, dry scrubbers, absorbers, adsorbers, baffle spray scrubbers, ejector venturi scrubbers, liquid-to-gas ratio scrubbers,
25 mechanically aided scrubbers, spray towers, spray nozzles, strippers, dry Electro-Static Precipitators, wet Electro-Static Precipitators, and venturi scrubbers.

In the above embodiments, the abatement apparatus comprises only a single washer, i.e. scrubber, which is common to or shared by the multiple
30 burner modules. However, in other embodiments, the abatement apparatus comprises a different number of scrubbers, each arranged to receive gas from the drainage tank. In other words, the abatement apparatus may comprise multiple scrubbers e.g. 2, 3, 4, 5, 6, 7, 8, 9, or 10 scrubbers, each of which

receives input gas from each of the burner modules. The multiple scrubbers may be of the same type, e.g. the multiple scrubbers may be substantially identical to one another. Advantageously, the use of multiple scrubbers tends to increase capacity of the abatement apparatus compared to if only a single
5 scrubber of the same size was used. The use of multiple scrubbers tends to increase capacity of the abatement apparatus while avoiding the use of larger size/capacity scrubbers. The use of larger size/capacity scrubber may affect the scrubbing of gases and/or operation of downstream (or indeed upstream) entities in a detrimental way, or in a way that is difficult to predict. Nevertheless,
10 in some embodiments a smaller number of larger size/capacity scrubbers may be implemented.

In the above embodiments, the burner modules of the abatement apparatus are substantially identical to each other. However, in other embodiments, one or more of the burner modules is different to one or more of
15 the other burner modules.

In the above embodiments, quenches are used to cool the combusted process gas. However, in other embodiments, one or more different types of coolers are used to cool the combusted process gas instead of or in addition to one or more of the quenches.

20 In some embodiments, the abatement apparatus comprises one or more further subsystems not described above. For example, the abatement apparatus may comprise one or more equipment or subsystems selected from the group consisting of: thermal reactors, burn boxes, catalytic units, plasma units, filters, scrubbers, absorbing and adsorbing units, cooling chambers, acid-
25 gas scrubbers, etc.

CLAIMS

1. An abatement system for abating process gas received from a process chamber, the abatement system comprising:
 - a plurality of burner modules, each burner module comprising:
 - 5 a respective burner for receiving the process gas and combusting the process gas in oxygen; and
 - a respective cooler coupled to the burner of that burner module, each cooler being configured to cool the combusted process gas output by the burner to which that cooler is coupled; and
 - 10 a common scrubber configured to receive combusted and cooled process gas from each of the plurality of burner modules, and to remove one or more substances from the received combusted process gas.
2. The abatement system of claim 1, further comprising a tank arranged to
15 collect liquid output by the plurality of burner modules and/or the common scrubber.
3. The abatement system of claim 2, wherein the tank is coupled between the plurality of burner modules and the common scrubber.
20
4. The abatement system of claim 2 or 3, wherein the tank comprises a plastic.
5. The abatement system of any of claims 1 to 4, wherein at least one of
25 the coolers is a quench.
6. The abatement system of any of claims 1 to 5, wherein each of the burner modules comprises a respective plurality of nozzles arranged to receive

the process gas and to introduce the received process gas into the burner of that burner module.

7. The abatement system of any of claims 1 to 6, wherein the burner
5 modules are substantially identical.

8. The abatement system of any of claims 1 to 7, wherein the common
scrubber is a scrubber selected from the group of scrubbers consisting of: wet
scrubbers, dry scrubbers, absorbers, adsorbers, baffle spray scrubbers, ejector
10 venturi scrubbers, liquid-to-gas ratio scrubbers, mechanically aided scrubbers,
spray towers, spray nozzles, strippers, dry Electro-Static Precipitators, wet
Electro-Static Precipitators and venturi scrubbers.

9. The abatement system of claim 8, wherein the common scrubber is a wet
15 scrubber.

10. The abatement system of any of claims 1 to 9, wherein the burner
modules are configured to operate in parallel with each other.

20 11. The abatement system of any of claims 1 to 10, wherein the burner
modules are configured to operate independently from each other such that one
of the plurality of burner modules may be in an "on" state while another of the
plurality of burner modules is in an "off" state.

25 12. The abatement system of any of claims 1 to 11, wherein the abatement
system comprises exactly two burner modules.

13. The abatement system of any of claims 1 to 12, wherein the abatement
system comprises exactly one scrubber.

14. A vacuum pumping and abatement system for evacuating process gas from a process chamber and abating the process gas, the system comprising:

5 a vacuum pumping system for evacuating process gas from the process chamber; and

an abatement system for abating the process gas evacuated from the process chamber; wherein

the abatement system is in accordance with any of claims 1 to 13.

10 15. A method for abating process gas received from a process chamber, the method comprising:

receiving, by each of a plurality of burner modules, the process gas, each burner module comprising a respective burner and a respective cooler coupled to the respective burner;

15 combusting, by the burners, the process gas in oxygen;

cooling, by the coolers, the combusted process gas;

receiving, by a common scrubber, combusted and cooled process gas from each of the plurality of burners; and

20 removing, by the common scrubber, one or more substances from the received combusted process gas.

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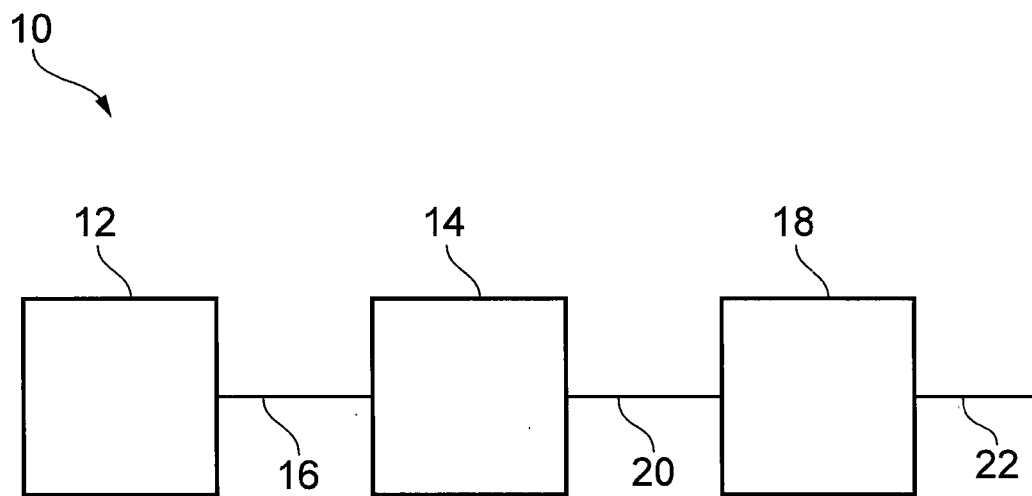


FIG. 1

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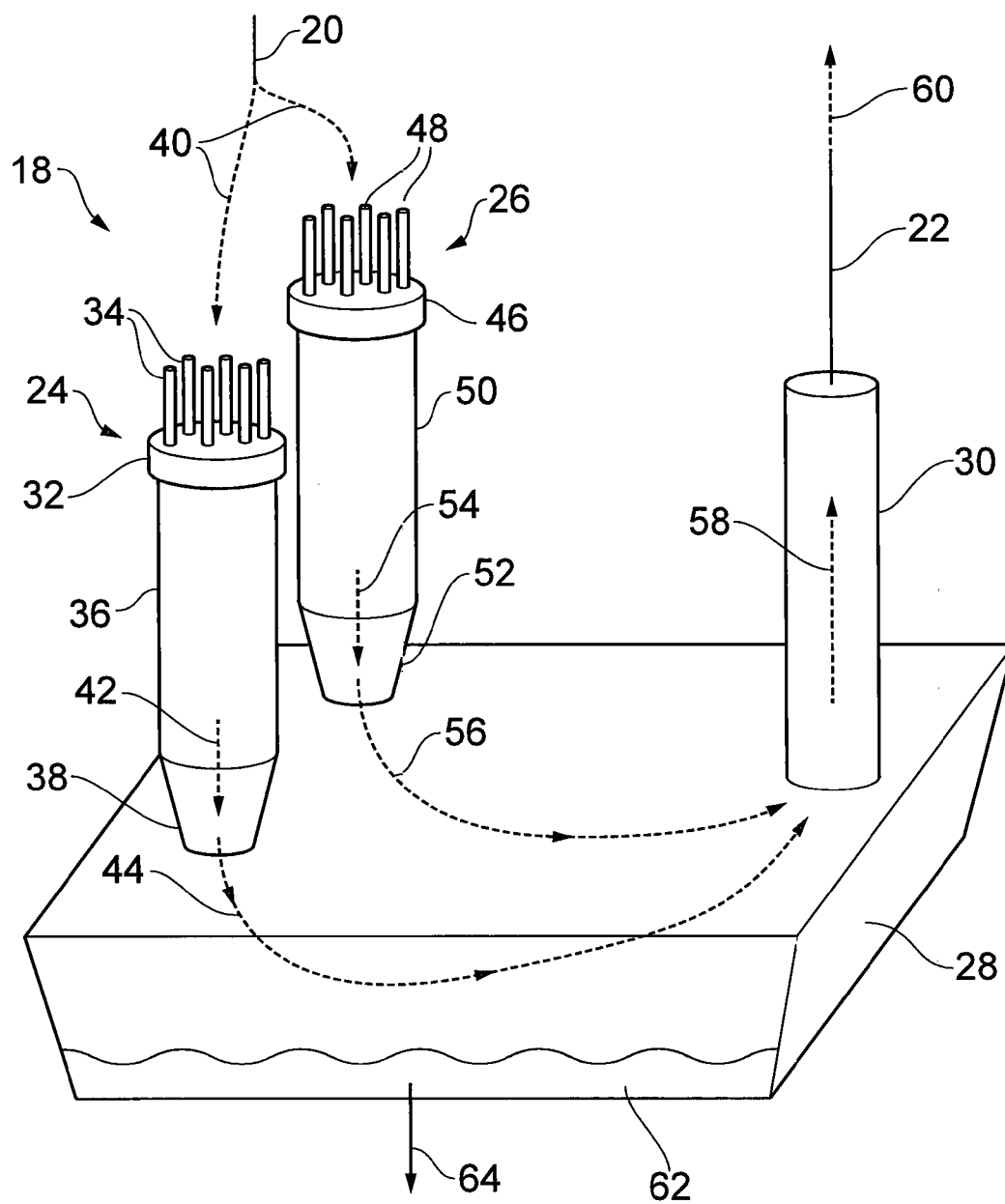


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/051862

A. CLASSIFICATION OF SUBJECT MATTER

INV. F23C6/02 F23D23/00 F23G7/06 F23J15/04 F23J15/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F23C F23D F23G F23J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/060759 A1 (MOORE ROBERT R [US]) 15 March 2012 (2012-03-15)	1-5, 7-13,15
Y	page 4, paragraph 69 - page 5, paragraph 73 page 5, paragraph 76 page 8, paragraph 97 figures 1,4,9	6,14
Y	----- US 2010/119984 A1 (FOX ALLEN G [US]) 13 May 2010 (2010-05-13) page 2, paragraph 23 - paragraph 25 figures 2-4	6
Y	----- US 2005/142010 A1 (BAILEY CHRISTOPHER M [GB] ET AL) 30 June 2005 (2005-06-30) page 4, paragraph 50 - page 5, paragraph 64 figure 1 -----	14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 August 2019

Date of mailing of the international search report

06/09/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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