(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 748 983 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.12.1996 Bulletin 1996/51

(51) Int. Cl.^{6}: **F23G 7/00**, F23C 9/06

(21) Application number: **96200757.1**

(22) Date of filing: **19.03.1996**

(84) Designated Contracting States:
DE DK FI FR GB

(30) Priority: **12.06.1995 IT MI951242**

(71) Applicant: **FINMECCANICA S.p.A. AZIENDA ANSALDO**
I-16128 Genova (IT)

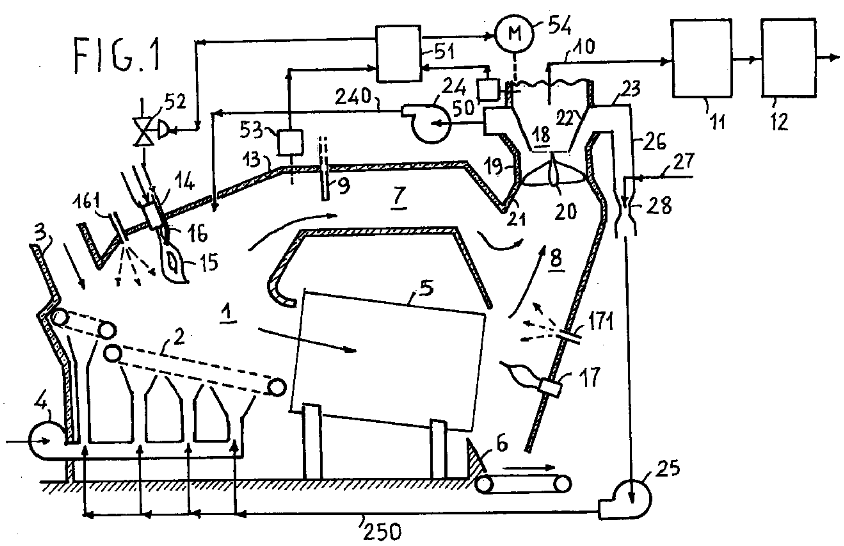
(72) Inventors:
- **Frontini, Luis Emilio**
  16149 Genova (IT)
- **Repetto, Francesco**
  16161 Cogoleto, Genova (IT)

(74) Representative: **Falcetti, Carlo et al**
c/o JACOBACCI & PERANI S.p.A.
Via Visconti di Modrone, 7
20122 Milano (IT)

(54) A waste incineration plant with dust collection and removal of acid compounds, particularly HC1

(57) A waste incineration plant with a combustion chamber (1, 8) and a heat-recovery boiler (11) in which basic material is introduced into the combustion chamber (1, 8) to initiate the removal of the acid compounds from the combustion gases under hot conditions by their conversion into salts, and in which an axial cyclone (18) in the path of the gases between the combustion chamber (1, 8) and the heat-recovery boiler (11) captures a considerable proportion of the solid particles in the gases including the fly ash and basic material for their return to the combustion chamber where an excess of the basic material over the stoichiometric quantity required for the conversion reaction is formed, with a favourable effect on the conversion yield, while downstream of the cyclone (18) the residual basic material in the gases is substantially in the stoichiometric ratio with the remaining acid substances and there is practically no fly ash, giving a substantial reduction in the re-synthesis of toxic halogenated organic compounds such as dioxins and furans, with a considerable substantial reduction in their formation.

FIG.1



EP 0 748 983 A1

Printed by Rank Xerox (UK) Business Services
2.13.10/3.4

Description

The present invention relates to a waste incineration plant with dust collection and removal of the acid compounds, particularly HCl, from the fumes under hot conditions.

It is known that fumes rich in acid compounds, particularly HCl, and unburnt solid particles are generated in waste incineration plants.

These porlutants must be removed before the fumes are released into the atmosphere, as must also toxic compounds such as dioxins and furans which result from catalytic interactions between the fly ash and acid precursors such as HCl during the cooling of the fumes.

As is known, it has been proposed to destroy acid compounds in the fumes from incineration plants and heat-generating plants with the use of basic compounds, such as $CaCO_3$, which are injected into the combustion chamber or a post-combustion chamber and, in mixing with the combustion gases, react with the acid compounds, such as HCl and SO_2, therein to form salts.

Since the neutralisation occurs from the first stage in the formation of the acid compounds and, hence, under hot conditions, numerous advantages are achieved which are mentioned, for example, in European Patent Application EP-A-0605041 which describes a process for removing acid compounds from the hot gases in which a basic material is injected into the flame produced by a burner in the plant.

In order to remove dust from the fumes, use is generally made of electrostatic filters, bag filters, cyclones and scrubbers located in the path of the combustion gases immediately before their emission into the atmosphere.

In this case it is desirable to remove the dust as far upstream as possible in the path of the gas.

European Patent Application No. 94203404.2 filed on 23.11.94 describes, for example, a hot filtration system in which an axial cyclone, or swirler, located immediately downstream of the combustion chamber and upstream of apparatus for recovering heat from the gas, divides the gas flow into a first fraction containing a relatively small quantity of extremely small particles and a second fraction rich in larger particles, which is subjected to a second filtration process and, thus purified, is then used for the recovery of heat from the gases.

It would be desirable to combine systems for the destruction of acidity in the hot gases with systems for the collection of dust from the hot gases in order to achieve the joint advantages of the two systems but this would involve considerable compensation.

One must in fact remember that the basic materials most commonly used to neutralise acidity under hot conditions are in the solid state, in the form of finely ground powders.

Thorough dust collection from the hot gases immediately downstream of the combustion chamber would thus free the fumes of the solid particles including the basic materials needed to salify the acids along the entire gas flow-path.

The destruction of the acid substances would then be confined essentially to the combustion chamber, giving a relatively low conversion yield, limited by a very short reaction time (transit time of the gases through the combustion chambers) and by the thermodynamic equilibrium of the conversion reaction which is displaced considerably towards the conservation of the acid compounds at high temperatures.

In order to avoid this problem it would be necessary to devise a system in which further basic material is injected downstream of the dust-collecting cyclone in order to enable the salification to continue along the flow-path of the gases.

This would require a more complex plant, with increased costs, considerable wastage of the basic material and operating costs which cannot be ignored.

All these problems are avoided by the waste incineration plant with removal of dust and acid compounds, particularly HCl, from the hot fumes which is the subject of the present invention. The plant, as well as avoiding the problems indicated above, achieves significant synergic effects between the two processes and in particular:

- The plant can be operated with an initial concentration of basic material in the hot gases in the combustion chamber and the post-combustion chamber which is very high, of the order of 2-10 times the stoichiometric ratio with the acid compounds to be neutralised.

As will be explained below, this results in a substantial increase in the removal of the acid compounds at high temperature (800-1100°C and even higher) in the combustion and post-combustion chambers. As a consequence, the concentration of the acid compounds leaving the post-combustion chamber is reduced drastically and requires the transport of a much smaller quantity of basic material, close to the stoichiometric ratio, in the gas flow.

- The plant allows the excess basic material to be recovered and reused while hot, without wastage of energy and materials. It must be remembered that the basic material, for example $CaCO_3$ or $Ca(OH)_2$, before reacting with the acid compounds, undergoes a conversion process with absorption of energy, in accordance with the equations

$$CaCO_3 = CaO + CO_2$$

$$Ca(OH)_2 = Ca + H_2O$$

The heat absorbed in the reactions is obviously taken from the heat evolved in the combustion process and adds to the heat absorbed by the basic compounds in their heating from their initial temperature, close to the ambient temperature, up to the temperature of the gases into which they are injected.

- The plant allows the recovery and use of the unburnt solid particles in the gases, these being subjected to a second incineration process, with an increase in the combustion yield and the removal, from the hot gases, of the fly ash which would constitute a catalytic substrate for reactions which result in the synthesis of particularly toxic, halogenated organic compounds such as dioxins and furans during the cooling of the fumes.

These advantages are supplemented and enhanced by the advantages intrinsic to the systems for the filtration and removal of acidic compounds under hot conditions set out specifically in EP-A-0605041 and in EP-A-0659462 and claimed below.

All these advantages are achieved, according to the invention, by a refuse incineration plant in which basic compounds are introduced into the combustion chamber and/or the post-combustion chamber directly or by means of basic burners, for example of the type described in EP-A-0605041 (flame generating burners into which basic compounds in powder form or in solution are injected) and in which an axial cyclone or swirler located immediately downstream of the post-combustion chamber captures a fraction (10-15%) of the gas flow, which is returned to the combustion chamber or the post-combustion chamber, reducing the unburnt materials and utilising the unreacted basic materials.

In the combustion and post-combustion chambers, the acid compounds, which are in gaseous form in the combustion fumes, are salified to a great extent (with conversion yields even of 70%) and assume the solid or liquid state which enables a large proportion thereof to be captured in the axial cyclone together with a considerable quantity of the excess basic material and fly ash.

The proportion of the fumes not captured and largely purified of solid particles and acidic compounds, proceeds without substantial load losses through the axial cyclone to the heat-recovery boiler and any subsequent heat exchangers where the destruction and removal of the acidic compounds is completed at decreasing temperatures thanks to the remaining basic material in the gases which is at concentrations close to the stoichiometric ratio.

The gas fraction captured by the axial cyclone, containing a high concentration of fly ash, salts produced by the neutralisation of the acidic compounds and excess basic material, is reintroduced, without filtration, by means of a blower or equivalent means into the combustion chamber and/or post-combustion chamber, where the basic material in the recycled fraction supplements that injected into the basic burner so as to bring its concentration to a much higher value than the stoichiometric ratio while the fly ash undergoes a second combustion process and the salts produced by the neutralisation reaction are concentrated in the solid combustion waste and discharged therewith.

The characteristics and advantages of the invention will become clearer from the description which follows and from the appended drawings, in which:

Figure 1 is a schematic general view of a first type of waste incineration plant with dust collection from the hot gases and destruction of the acid compounds under hot conditions in accordance with the present invention;
Figure 2 is a flow diagram showing the input and output of acid and basic compounds to and from a combustion chamber and a dust-collection device of the plant of Figure 1 operating under hot conditions;
Figure 3 is a schematic elevational view of a variant of dust-collection apparatus of the plant of Figure 1;
Figure 4 is a schematic general view of a second type of waste incineration plant with dust collection and destruction and removal of acid compounds from the combustion gases under hot conditions in accordance with the present invention.

With reference to Figure 1, a waste incineration plant is illustrated having a furnace with a grate and two pathways for the gases (also known as a Volund furnace).

The combustion chamber 1 houses a movable grate 2 on to which the refuse to be burnt is fed through a loading aperture 3.

A blower 4 supplies the combustion chamber with combustion air through the grate 2.

Suitable burners, not illustrated, initiate the combustion reaction. Partial combustion of the refuse occurs on the grate with excess air.

The combustion mixture is conveyed to a rotary drum 5 where combustion is completed with the excess air, possibly with the aid of post-burners which raise the temperature of the solid waste and cause it to vitrify.

The solid waste leaving the drum is discharged into a hopper 6 from which it is removed either periodically or continuously by conventional systems.

To facilitate combustion of the remaining refuse in the drum 5, a proportion of the gases resulting from the partial combustion reaction, including excess air, is passed through the drum 5.

The remaining proportion of the gases from the partial combustion reaction, including excess air, flows through a by pass 7 past the drum 5 to a post-combustion chamber 8 into which the gases leaving the drum 5 also flow.

A regulating lock 9 and any other locks, not illustrated, at the inlet and/or outlet of the drum 5 enable the proportions of the gas flows along the two pathways to be controlled.

Since the temperature of the combustion gases is greatly influenced by the calorific content of the waste to be burnt, which is extremely variable, burners, not illustrated, supplied with secondary combustion air and fuel oil, located in the top of the combustion chamber or in the post-combustion chamber help to raise and regulate the temperature of the gases in the post-combustion chamber 7 to a value of the order of 950° to 1000°C or more.

The hot gases 10 leaving the combustion chamber then pass through heat-recovery apparatus 11, such as a boiler and heat exchangers, and subsequently through apparatus for filtering and removing acid substances, such as scrubbers and electrostatic filters, shown collectively by the block 12.

All this apparatus is known per se and conventional and does not require further explanation.

In a plant of this type, the gases leaving the combustion chamber, loaded with fly ash and acid compounds, pass through the heat-recovery apparatus 11 and subject it to serious corrosive effects and accumulation of dust with a consequent reduction in its heat-exchange efficiency.

The gas leaving the heat recovery apparatus 11 cannot be at a temperature below 200-250°C if condensation and wet acid attack are to be avoided and the filtration or scrubbing assemblies are expensive, bulky and require frequent maintenance.

In addition to these problems, the fly ash transported in the gas constitutes a catalytic substrate for the resynthesis of halogenated organic compounds such as dioxins and furans, which are particularly toxic, the reactions taking place during the cooling of the gas.

According to the invention, these serious problems are eliminated by the combined use of at least one injection device, preferably but not necessarily a basic burner of the type described in EP-A-0605041, for the injection of basic compounds into the combustion chamber and/or post-combustion chamber, an axial cyclone or swirler for capturing a substantial proportion of the solid particles, disposed immediately downstream of the post-combustion chamber, and means for returning the captured solid particles to the combustion chamber and/or post-combustion chamber.

As shown in Figure 1, a nozzle 161 for injecting basic material, either in powder form or in aqueous dispersion, directly into the combustion gases is located in the top 13 of the combustion chamber of the furnace.

The basic material preferably used because of its cheapness is calcium carbonate ($CaCO_3$) ground to a suitable particle size which may be selected within wide limits, from 40 μ to 500 μ and preferably between 50 and 100 μ.

The particle size of the material plays an essential role in the salification of the acidic compounds which occurs in heterogeneous conditions (reaction between solid and gas). The finer the particle size, the greater the ratio of the surface area to the volume of the solid reagent in contact with the acidic gases in the fumes, increasing the rate of reaction.

This is offset by higher grinding costs and lesser fluidity which makes transport more difficult.

It is found that, with direct injection of powdered calcium carbonate into the flame nucleus, the mineral undergoes rapid calcination and decomposition into CaO and CO_2 without the phenomenon of dead burning occurring.

On the contrary, further fragmentation, or flashing, of the solid particles occurs due to the sharp increase in surface temperature to which the granules are subject when injected into the hot gases, which results in the formation of solid particles with dimensions of the order of 10-20 μ and, in some cases, even less than 10 μ.

The optimum particle size for direct injection of $CaCO_3$ into gases at a temperature of 900-1000°C is between 50 and 100 μ and it is found that such material is readily conveyed by screws and air injectors.

If the gas temperature is lower, it is convenient and preferable to inject the basic material by means of basic burners of the type described in EP-A-0605041.

As shown in Figure 1, a burner 14 of this type supplied with fuel and combustion gas, for example diesel oil and air, develops a flame 15 with a hot nucleus at a relatively high temperature of the order of 1600-1800°C.

The burner 14 has a nozzle 16 for the injection of a basic material, in powdered form or in solution, directly into the hot nucleus of the flame 15.

In this case the calcining and/or dehydration and the flashing occurs in a very short space of time, of the order of a fraction of a second, while the basic compound is in the hot flame, without dead burning and wastage of the heat energy of the flame which, as well as achieving the calcining, may also contribute to bringing the temperature of the gases to the desired value.

In this case one may conveniently use basic material having a particle size greater than 100 μ.

In addition or as an alternative to the injector 161 or the burner 14, an injector 171 or a basic burner 17 of the same type may be installed in a wall of the post-combustion chamber 8, preferably facing the outlet from the drum 5.

In refuse incineration plants, the acid compound present in greatest concentration is HCl and reference will be made to this below.

The calcium oxide and hydrogen chloride in the fumes react together in accordance with the reaction

$$CaO + 2HCl = CaCl_2 + H_2O \qquad (1)$$

This equation is not, however, sufficient to describe the phenomenon.

In practice, the salification occurs with a rate of reaction which is linked to the concentrations of the components, the temperature and the physical state of the reactants.

The introduction of $CaCO_3$ or $Ca(OH)_2$ into the fumes at high temperature and their conversion to CaO allow the salification to start right from the first stage of formation of HCl, thus maximising the reaction time available, which corresponds to the time in which the gases pass through the combustion chamber to the outlet of the plant.

The reaction rate is also increased by the high temperature occurring initially.

The resulting advantage is not, however, substantial since at high temperatures, of the order of 800-1000°C, the thermodynamic equilibrium of the salification reaction (1) is displaced considerably to the left.

In practice, with equal concentrations of the base CaO and of the acid HCl or with a slightly greater than stoichiometric ratio, the conversion efficiency is of the order of 10%.

This means that the hot fumes leaving the post-combustion chamber, which flow over the heat-recovery boiler, still contain a significant quantity of acidic compounds.

Notwithstanding the fact that the thermodynamic yield of the reaction (1) is very low at the initial temperature of the process, it is possible to achieve high conversions of the hydrogen chloride if the base CaO is in excess of the stoichiometric ratio of the CaO to HCl.

In practice, with excess CaO of the order of 200-600% it is theoretically possible to achieve conversion yields of even as much as 70 to 80% and this has in fact been found experimentally.

This results in another type of problem: apart from the fraction of acid substances which reacts by surface contact with the walls over which the fumes flow and with the basic reagent, the acidic substances, such as HCl, are in the gaseous state and hence transported in the gases, but the basic material, such as CaO, is in the solid, powdered state and tends to be deposited on the walls where it forms considerable accumulations which reduce the heat-exchange efficiency.

As shown in Figure 1, this problem is eliminated by the insertion of an axial cyclone 18 in the path of the fumes between the post-combustion chamber 8 and the heat-recovery boiler 11.

The axial cyclone is constituted by a cylindrical tube 19 with an inlet nozzle 21 which houses a swirler 20 within it.

At a suitable distance downstream of the swirler 20, coaxial with the tube 19, is an annular tube 22 of a diameter conveniently less than that of the tube 19 and conveniently shaped so as to form a divergent nozzle and a chamber 23 for confining a secondary flow.

The swirler 20, by means of its blades, imparts a rotary component of movement to the gas which enters the nozzle 21 in an axial direction.

This rotary component gives rise to a centrifugal effect which causes the solid particles transported by the gas flow towards the tube 22 to accumulate mainly in a peripheral layer of the flow.

The tube 22 has the effect of dividing the gas flow into two parts: the first part, corresponding to the central section of the flow, enters the tube 22, continuing its axial movement indicated by the arrow 10.

The second part, corresponding to the annular portion of the flow is captured between the tube 19 and the tube 22 and conveyed to the confinement chamber 23 from which it is withdrawn by suitable suction means.

These may, as shown in Figure 1, consist of a first fan 24 and duct 240 which convey the captured fraction of the gas (termed the secondary flow below) or part of this to the combustion chamber through the top of the latter, and/or a second fan 25 and duct 250 which convey part or all of the secondary flow to the conveyor grate 2 for the solid waste where it mixes with the combustion air blown in by the blower 4.

For reasons which will be explained below, the secondary flow 26, which is at a high temperature of the order of 1000°C, may be supplemented by cooler, secondary combustion air 27 which lowers its temperature before its input to the fan 25.

With the use of a Venturi-effect mixer 28, the fan 25 and also the fan 24 may be rendered superfluous.

Moreover, if return ducts, such as the ducts 240, are used which are so dimensioned that the speed of the secondary flow 26 is lower than the speed of the gases entering the cyclone, a fraction of the kinetic load of the secondary flow may be converted into static load which at least partly helps to support the secondary flow towards the combustion chamber.

The axial cyclone may conveniently be dimensioned so that the secondary gas flow is about 10% of the total flow and the efficiency of capture of solid particles is of the order of 95%.

Figure 2 is a block-schematic diagram showing the quantitative molar balance between the flows into/out of the combustion chamber/post-combustion chamber 29 and the axial cyclone 30 of a plant such as that of Figure 1 and, with several simplifications introduced purely for clarity, enables the operating conditions of the plant to be defined.

HCl indicates the molar flow rate of HCl which is formed during the incineration of the waste.

CaO indicates the molar flow rate of CaO which is introduced into the combustion chamber through the basic burners and which is assumed to be in unitary stoichiometric ratio with the HCl flow rate.

CaO (E) indicates the molar flow rate of CaO which is captured by the axial cyclone 29 and returned to the combustion chamber.

CaO(E) represents a flow rate which is in excess of the stoichiometric flow rate and E defines the excess ratio.

It is clear that there is a higher CaO concentration in the combustion chamber with a molar ratio to the HCl concentration of 1 + E.

The yield of the process with regard to the destruction, or removal, of HCl in the boiler is indicated η, the fraction of HCl which is salified is HCl.η and the fraction of CaO consumed in the process is CaO.η, although in practice it is somewhat higher for reasons explained below.

The flow rate of HCl leaving the combustion chamber is thus given by HCl(1-η) and that of CaO by CaO(1-η+E).

The volumetric fraction of the flow captured by the cyclone is termed α while the fraction of solid particles captured is given by β and the flow rate of the HCl which is transferred to the heat-recovery boiler is given by $HCl(1-\eta).(1-\alpha)$.

The CaO fraction transferred to the heat-recovery boiler is given by $CaO(1-\eta+E)(1-\beta)$.

A negligible fraction of HCl, equal to $HCl(1-\eta).\alpha$, is returned to the combustion chamber together with a significant fraction of CaO, equal to $CaO(1-\eta+E).\beta$, which constitutes the CaO excess E.

Hence $E = (1-\eta+E).\beta$ or:

$$E = (1-\eta)\beta/(1-\beta).$$

The excess CaO in the combustion chamber is thus a function of the ratio β of capture of the solid particles and the destruction yield η.

If, as stated, the yield η is 0.7 and β is 0.95, the excess CaO which forms in the combustion chamber is about 6 which is such as to ensure the yield indicated.

It may be noted that the fraction of HCl transferred to the heat recovery boiler if $\alpha = 0.1$ is about 0.3 times the flow rate of HCl formed in the combustion chamber and the CaO fraction which accompanies the HCl and which is not captured by the cyclone is also about 0.3 times the stoichiometric quantity of CaO introduced into the combustion chamber.

In other words, the flow to the heat-recovery boiler contains CaO and HCl in the stoichiometric ratio, the HCl concentration having been reduced to less than a third of its initial value.

In the heat-recovery apparatus, the temperature of the gas falls and hence the destruction of the HCl continues, giving high yields, even of the order of 80% and with minimum formation of deposits, even in the presence of CaO in the stoichiometric ratio.

Hence, at the outlet of the heat-recovery apparatus, the HCl concentration in the gas is considerably reduced, down to about 6% of the initial value, and may, if necessary, be further reduced in a scrubber of smaller dimensions and at little expense.

In the plant described, the maximum conversion yield is thus obtained with the use of a minimum quantity of basic material, substantially equal to the stoichiometric quantity needed.

In practice one must remember that the salt, $CaCl_2$, formed in the salification of the HCl with CaO has a fusion point of about 774°C and calcium oxide is soluble in $CaCl_2$ with the formation, at 750°C, of a eutectic mixture containing about 6% CaO.

At temperatures above 750°, in the presence of excess CaO, a liquid phase of $CaCl_2$ saturated with CaO is formed.

The consumption of CaO is thus rather greater than (about 1.2 times) that given by the stoichiometric ratio.

In order to minimise the consumption of CaO, and hence of $CaCO_3$, a further aspect of the present invention provides a regulatory system for modulating the molar flow rate of $CaCO_3$ in dependence on the concentration of the acid substances in the gases, which is proportional to the mass flow rate of the acid substances in the gases.

In a system such as that described, which operates with excess basic material, contained in a storage volume, or buffer, formed by the combustion chamber, the control cannot ensure that a predetermined ratio of the concentration of the basic material to that of the acid substances is mainted in the gases in real time but it ensures, in the long term, that quantity of the basic material introduced is exactly the stoichiometric quantity required by the reaction for salifying the acid substances (or in a predetermined ratio thereto) and is not in excess.

This regulatory system may be achieved in various ways.

For example, as shown schematically in Figure 1, a probe 50 may detect the concentration of acid substances in the main gas flow leaving the axial cyclone 18.

Since the destruction yield η of acid compounds in the presence of excess base is largely independent of the concentration of the acid substances, the probe 50 provides an indirect indication of the molar flow rate of the acid compounds formed in the combustion chamber.

There is obviously nothing to stop one measuring the molar flow rate of the acid compounds with a probe located in the combustion chamber.

The signal output by the probe 50 is applied to the input of a control unit 51 which generates a control signal for a regulating member, for example a modulating valve 52, which controls the flow of basic material immitted, purely by way of example, from the nozzle 16 or from any other nozzle provided for the injection of the basic material.

As an alternative, it is also possible to control the flow rate of the basic material so as to ensure a predetermined concentration thereof in the combustion chamber.

For this purpose a monitoring probe 53 for monitoring the concentration of the basic material may be arranged in the top 13 of the combustion chamber or at any other point therein, as long as it is downstream of the ducts for introducing the recycled basic material.

The two regulatory systems may be combined with each other to ensure a very quick dynamic response to variations in acidity and a slower corrective action in dependence on the concentration of the basic material.

A further regulatory action which may be carried out independently or together with the preceding actions, relates to the flow rate of the basic material accompanying the gases in their travel downstream of the axial cyclone.

Returning to the considerations given with reference to Figure 2 and related to the ratio between the remaining acidity and the basic material in the gas flow downstream of the cyclone, defined by $HCl(1-\eta)(1-\alpha)$ and $CaO(1-\beta)$ respectively, the mass flow rate of CaO is determined essentially by β for high values of E.

The desired ratio of HCl to CaO is thus achieved only for a predetermined flow rate of HCl.

If the mass flow rate of HCl varies, this ratio varies.

It is necessary to take account of this by ensuring that, for a predetermined value of β, the CaO flow rate is in the stoichiometric ratio with the HCl for the worst case of the maximum acidity envisaged in the gases.

This means that, for a lower acidity, the quantity of CaO in the gas is in excess.

To advantage it is therefore provided for the capture ratio β of the cyclone to be variable so that the quantity of CaO released from the axial cyclone can be regulated.

As shown in Figure 1, the control unit 51 controls a servomotor 54 which moves the divergent nozzle axially so as to vary the distribution ratio α of the axial cyclone.

Small variations in α correspond to large variations in β and it can thus be arranged that the CaO flow rate is adapted to the actual residual acidity of the gases moment by moment.

Instead of moving the divergent nozzle 22 axially, it is also possible to use a swirler with a variable pitch helix controlled by the unit 51 or to combine the two effects with each other.

The type of reaction product should now be considered.

The $CaCl_2$ which is formed as a mist in the gas in the combustion chamber at high temperature tends to coalesce into droplets which fall under gravity and mix with the incineration waste.

A good proportion of the $CaCl_2$ is thus removed from the plant with the solid waste.

Some of the remaining fraction transported by the gas is conveyed into the gas line from which it is removed periodically by conventional cleaning operations while some is captured by the axial cyclone and returned with the secondary gas flow to the combustion chamber.

In order to minimise the formation of scale on the walls of the recycling ducts, it may be appropriate to mix the secondary gas flow with cold air introduced into the confinement chamber 23 or immediately downstream thereof, this reducing the temperature to 700-720°C so as to favour the formation of powdery deposits of $CaCl_2$ rather than scale.

In the heat-recovery boiler, where the temperature of the gases falls below 750°C, the $CaCl_2$ forms mainly in the solid phase, as a powder, but in any case in limited quantities correlated with the residual HCl concentration, with minimal formation of deposits and scale.

It should be noted that the function of the axial cyclone is not only to capture the excess calcium oxide and the calcium chloride.

In general, all the solid particles carried by the gases, apart from the smallest particles, from 5 to 10 μ, and thus also the fly ash, are captured by the cyclone which returns them to the combustion chamber where they are subjected to a second combustion and incineration process.

A dual effect is thus achieved:

on the one hand the combustion and incineration of the waste is carried out more thoroughly, with an increased combustion yield; on the other hand the fly ash content of the gases leaving the combustion and post-combustion chambers is reduced substantially.

This is particularly advantageous not only because the deposits and scale in the heat recovery apparatus are reduced but also because the catalytic effect of the fly ash in the formation of toxic halogenated organic compounds such as dioxins and furans is suppressed, this taking place mainly during the cooling of the combustion gases.

The reduction in the toxic compounds is thus due to the combined effect of the chemical destruction of their acid precursors and the removal of the substrate which supports their renewed synthesis.

It is thus clear that the incineration plant described achieves a number of advantages:

- great efficiency in the reaction for the destruction of the acid compounds, which occurs mainly under hot conditions and continues through the entire transit of the gases, with concentrations of the basic material which are optimised for the various temperatures: in particular the transit time is, by way of example, 1-2 seconds in the combustion chamber, 2-3 in the heat-recovery boiler and 3-4 seconds in the line downstream, with a total transit time of the order of 6-9 seconds;
- a reduction in the quantity of toxic compounds evolved;
- a reduction in the corrosion and erosion caused by physico-chemical attack as well in the abrasion caused by the solid particles in all the apparatus downstream of the combustion chamber, with particular benefits as regards the overheating of the heat-recovery boiler (which is most prone to hot corrosion and to the formation of scale), with a substantial increase in its useful working life and the possibility of increasing its working temperature;
- a reduction in the dimensions and complexity of the equipment for filtering and scrubbing the fumes leaving the plant, which may be dimensioned so as to remove only the residual acidic compounds;
- the possibility of using common mineral salts, even insoluble ones such as calcium carbonate, as the basic material;
- an increase in the yield from the heat cycle of the plant due to the possibility of using all the enthalpy of the gases which is not normally utilised to avoid chemical attack and erosion;
- an increase in the combustion yield of the furnace;
- a reduction in the frequency of the cleaning operations needed for the heat-recovery boiler and the apparatus downstream thereof since a substantial proportion of the solid particles and the reaction salts is returned to the furnace and collected with

the solid waste;

- the possibility of redistributing the transverse velocity profile of the gases entering the heat-recovery boiler and thus optimising the heat-exchange efficiency.

With regard to this latter advantage it should be noted that the axial cyclone of Figure 1 may in practice be constituted by a battery of axial cyclones disposed in parallel and provided with blades whose angles of incidence can be adjusted, there being for example four (as shown schematically in Figure 39) or more.

By varying the angles of incidence of the blades of the various swirlers relative to each other it is possible to obtain different load losses and hence flow losses in the various swirlers.

The total flow may then be distributed in a convenient manner in the various flow sections.

Figure 1 shows only one preferred embodiment of an incineration plant which uses a Volund furnace.

It is however clear that the incineration plant of the invention may use other types of furnace.

Figure 4 shows an incineration plant according to the present invention which uses a rotary drum furnace.

The waste to be incinerated is discharged into a hopper 33 and conveyed by a screw 34 to the inlet of a rotary drum 35.

Combustion air is blown into the inlet of the rotary drum through suitable nozzles as shown by the arrow 36.

The outlet of the rotary drum 35 is connected to a hopper 37 for receiving and discharging the solid waste, above which is a vertical-axis post-combustion chamber 38.

At the base of the post-combustion chamber 38, a basic burner 39 burns secondary air and secondary fuel with the formation of a flame 40 and secondary combustion gas which mixes with the primary gas.

A nozzle 41 injects a basic material, such as calcium carbonate, into the flame 40 where it is calcined and reacts with the acidic compounds.

Again in this case, a simple injector may be used for injecting the basic material instead of the basic burner 39.

The gases 42 leaving the post-combustion chamber, at a high temperature, of the order of 900-1100°C, pass through an axial cyclone 43 like the cyclone 18 of Figure 1.

The fraction of the gas which is not captured, and which is largely purified of its solid particle (and liquid) content, passes through a heat-recovery boiler 44, where the destruction of the acid substances continues at lower temperatures and through scrubbing equipment 45 downstream of the boiler 44.

The fraction of the gas which is captured by the cyclone 43, and which contains most of the solid particles and the liquid present in the gases, is conveyed through suction ducts 46 to the base of the post-combustion chamber 38 and/or through ducts 47 to the inlet to the rotary drum 35.

Again in this case, the recycled fraction of the gas may previously be mixed with all or some of the primary combustion air introduced into the rotary drum or with the secondary combustion air introduced into the post-combustion chamber.

It is clear with regard to the above description that reference has been made specifically to the reaction with HCl but reactions also take place with other acidic substances such as SO_2, HF, HBr, generally present in much smaller concentrations.

Claims

1. A waste incineration plant including a combustion chamber (1, 8, 35, 38), where the waste is burnt with the formation of primary combustion gases rich in solid particles and acid substances, and a boiler (11) for recovering the heat from the gases, located in the path of the gases, including;

- immission means (14, 17, 161, 171) for introducing basic material into the combustion chamber (1, 8, 35, 38), the basic material mixing with the primary combustion gases,
- at least one axial cyclone (18) located in the path of the gases upstream of the heat-recovery boiler (11) for capturing a fraction α of the gas flow and a fraction β of the solid particle content of the gases, with $\beta > \alpha$, and
- means (24, 25, 28, 240, 250) for returning the captured fraction of the gas flow and the captured fraction of the solid particle content to the combustion chamber (1, 8, 35, 38).

2. An incineration plant as claimed in Claim 1, in which the means for introducing the basic material comprise a basic burner (14, 17) for generating a secondary combustion gas with the production of a flame, the basic burner (14, 17) having a nozzle (16) for immitting basic material into the flame, the secondary gas, rich in basic material, mixing with the primary combustion gases in the combustion chamber (1, 8, 35, 38).

3. An incineration plant as claimed in Claim 1 or Claim 2, in which the combustion chamber comprises a first combustion chamber (1, 35) and a second, post-combustion chamber (8, 38).

4. An incineration plant as claimed in Claim 1 or Claim 2, in which the combustion chamber (1) is constituted by a grate furnace with two gas pathways and a top (13) overlying the grate (2) and the return means include a duct (240) for returning the captured fractions of the gas flow and of the solid particles to the combustion chamber (1) through the chamber top (13).

5. An incineration plant as claimed in Claim 1 or Claim 2, in which the combustion chamber is constituted by a grate furnace with two gas pathways and with nozzles for blowing primary combustion air beneath the grate (2), and the return means include a duct (250) for returning the captured fractions of the gas flow and of the solid particles to the combustion chamber (1) beneath the grate (2).

6. An incineration plant as claimed in Claim 5, in which the captured fraction of the gas flow is mixed with at lease a primary fraction of the primary combustion air.

7. An incineration plant as claimed in Claim 3, in which the first combustion chamber is constituted by a rotary drum oven (35) with an inlet aperture.

8. An incineration plant as claimed in Claim 7, in which the return means include a duct (47) for returning the captured fractions of the gas flow and of the solid particles to the inlet aperture of the rotary drum (35).

9. An incineration plant as claimed in Claim 7, in which the return means include a duct (46) for returning the captured fractions of the gas flow and of the solid particles to the post-combustion chamber (38).

10. An incineration plant as claimed in the preceding claims, including a plurality of axial cyclones in parallel, the axial cyclones having swirlers with blades set at adjustable angles of incidence.

11. An incineration plant as claimed in any one of the preceding claims, in which the basic material immitted into the combustion chamber by the immission means is at least in the stoichiometric molar ratio with the acid compounds, and in which the captured solid particles include a basic powder resulting from the calcining and/or dehydration of the basic material in the combustion chamber and β is greater than 0.9 so that a concentration of basic powder in excess of the molar stoichiometric ratio with the acid compounds accumulates in the combustion chamber (1, 8, 35, 48).

12. An incineration plant as claimed in Claim 1, in which the basic material comprises powdered calcium carbonate with a particle size of between 50 and 100 μ.

13. An incineration plant as claimed in Claim 1 or Claim 2, including means (50, 51, 52, 53) for adjusting the molar flow rate of the basic material immitted into the combustion chamber as a function of at least one measured variable selected from the concentration of the acid substances in the gases and the concentration of the basic material in the combustion chamber.

14. An incineration plant as claimed in Claims 1, 2 or 13, including means (50, 51, 52, 54, 20, 22) for varying the fraction β captured by the cyclone in dependence on the concentration of the acid substances in the gases.

15. A control system for regulating the molar flow rate of the basic material for the waste incineration plant of Claim 1 or Claim 2, including means (50, 53) for measuring a variable selected from the concentration of the acid substances in the gases in the plant and the concentration of the basic material in a combustion chamber of the incineration plant and control means (51, 52) connected to the measuring means for controlling the rate of immission of the basic material into the combustion chamber in depedence on the variable measured.

16. A control system for regulating the flow rate of basic material carried by the gases of an incineration plant as claimed in Claim 1 or Claim 2 provided with an axial cyclone for capturing the solid particles in the gases leaving a combustion chamber of the plant, including means (50, 53) for measuring the concentration of the acid substances in the gases in the plant and control means (51, 54) connected to the measuring means for varying the fraction captured by the cyclone in dependence on the concentration of the acidic substances.

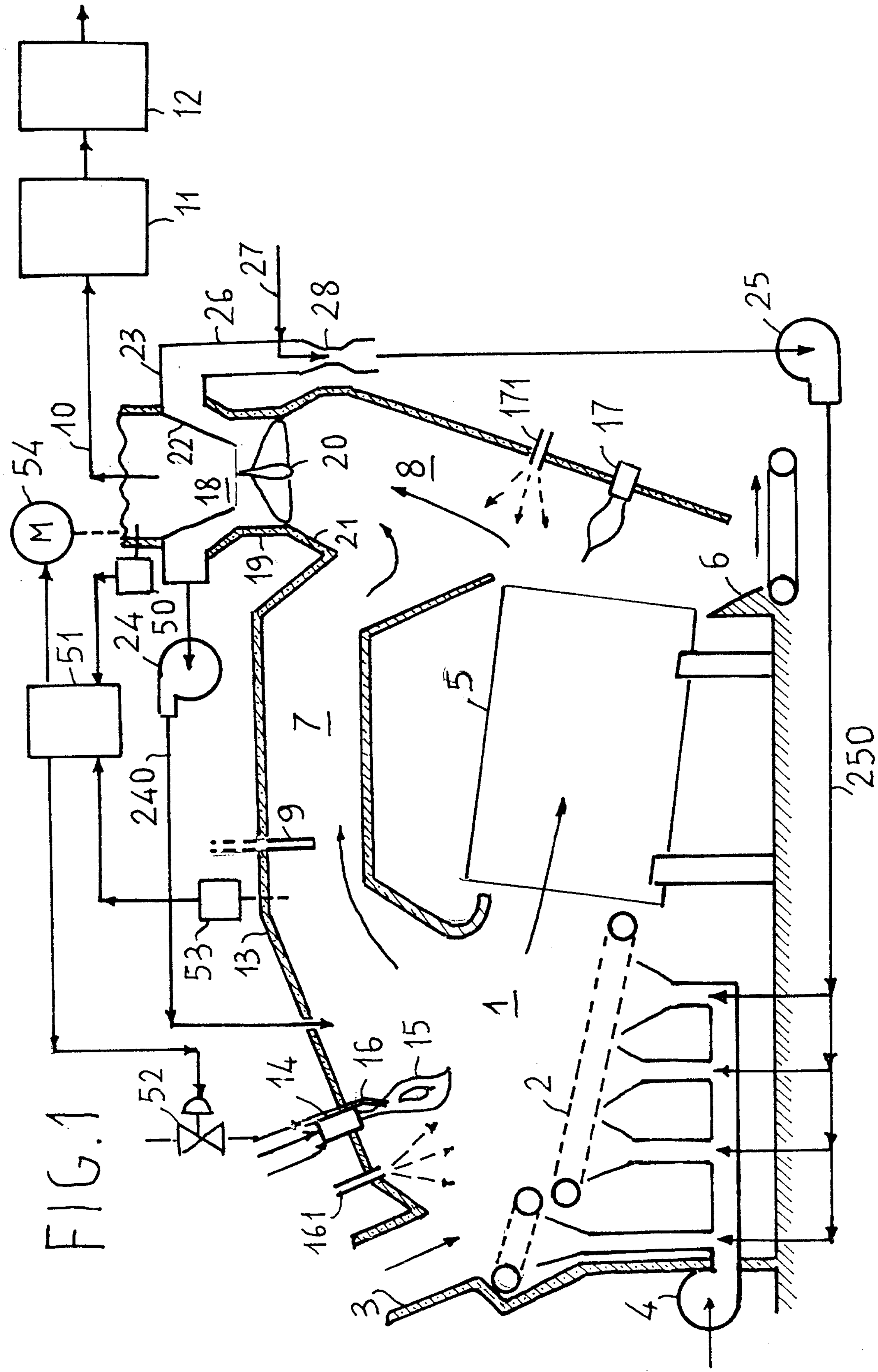
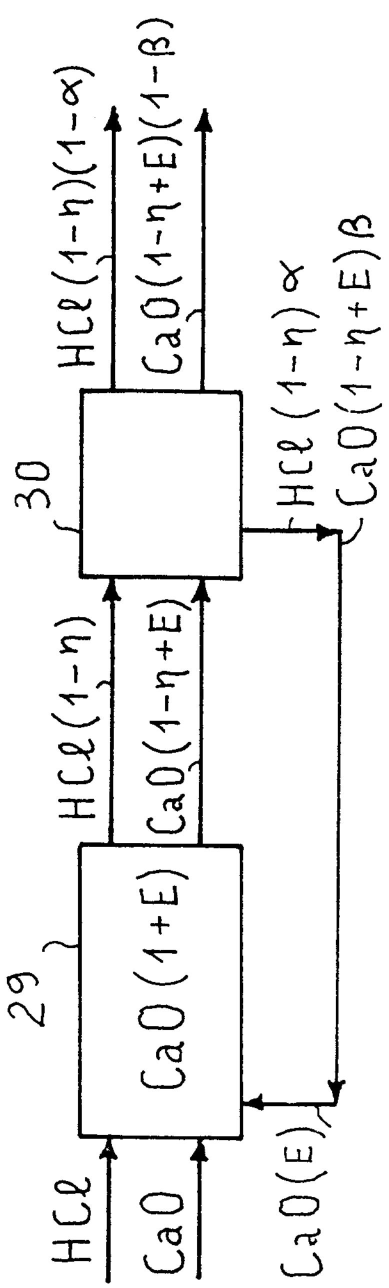

M
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
161
17
171
18
19
20
21
22
23
24
240
25
250
26
27
28
50
51
52
53
54

FIG. 1



HCl
CaO
CaO(E)
29
CaO(1+E)
HCl(1-η)
CaO(1-η+E)
30
HCl(1-η)(1-α)
CaO(1-η+E)(1-β)
HCl(1-η)α
CaO(1-η+E)β

FIG. 2

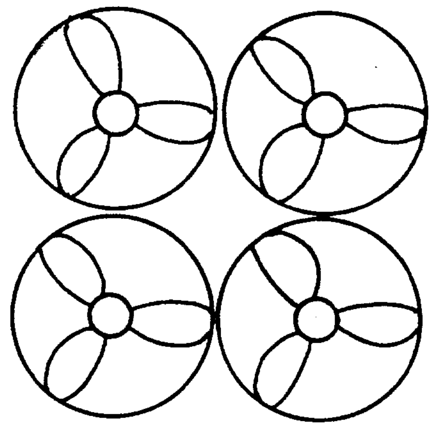


FIG. 3

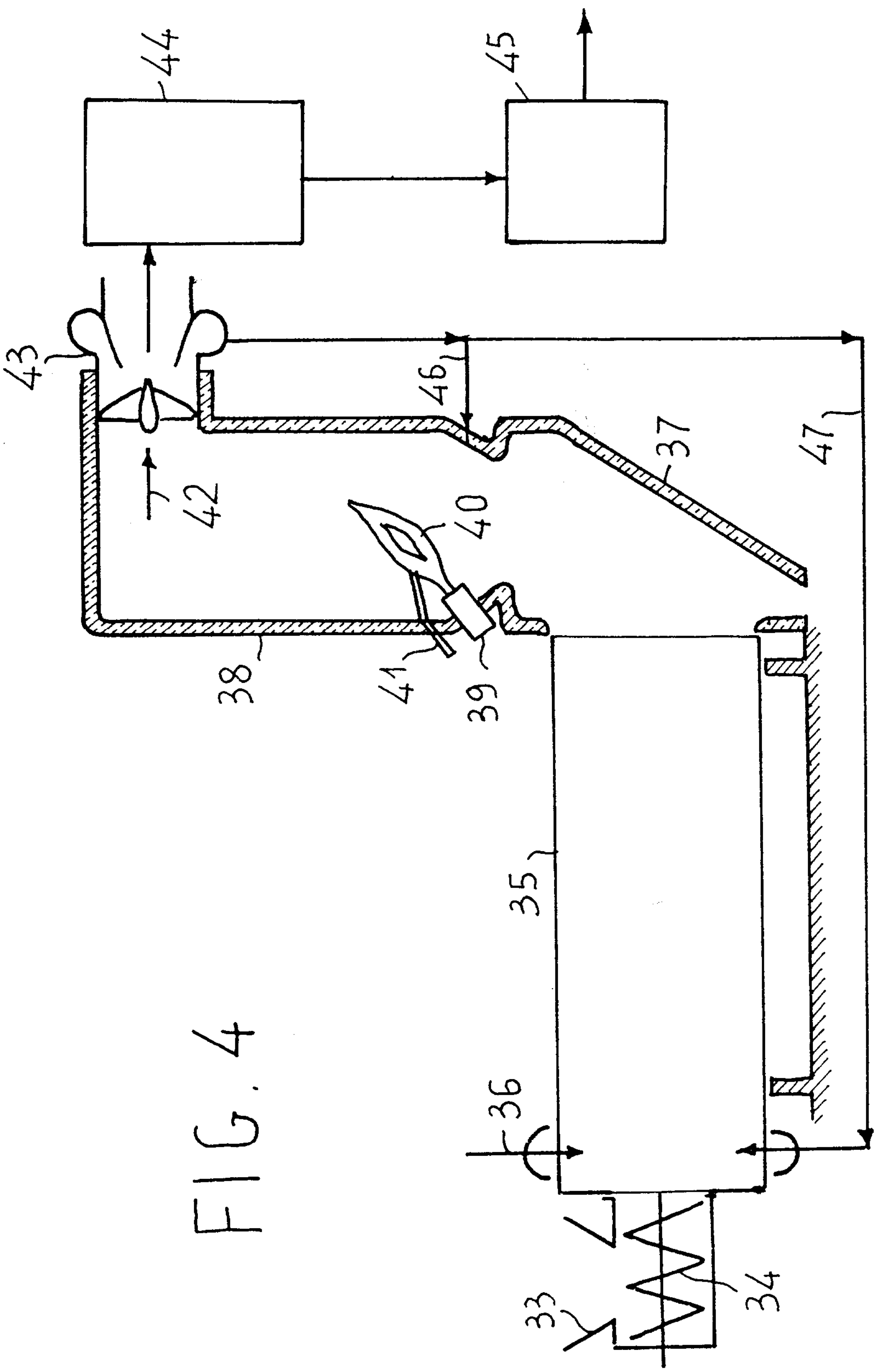


FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 96200757.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 6)
Y	DE - A - 3 434 970 (THERMO ANLAGEN-TECHNIK MIEHE GMBH) * Claims 1,10; page 8, paragraph 3, lines 5-7; page 14, last paragraph, lines 6-10; fig. 1,2 *	1-5	F 23 G 7/00 F 23 C 9/06
A		10	
Y	DE - C - 3 741 842 (L&C STEINMÜLLER GMBH) * Claims 1-6; column 2, lines 48-57; column 3, lines 36-57; column 4, lines 8-14,30-35; fig. 1 *	1-5	
A		6-9,11	
D,A	EP - A - 0 659 462 (FINMECCANICA S.P.A. AZIENDA) * Claim 7 *	10	
D,A	EP - A - 0 605 041 (ANSALDO-UN'AZIENDA FINNMECCANICA) * Claims 1,5 *	1,12, 13,14, 15,16	TECHNICAL FIELDS SEARCHED (Int. Cl.6) F 23 G 5/00 F 23 G 7/00 F 23 C 9/00 F 23 J 7/00 B 01 D 50/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	27-08-1996	BISTRICH

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)