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Description

[0001] This invention relates to thermal decomposition processes such as the destruction of toxic waste matter, and is concerned with both a process and apparatus. It will be convenient to hereinafter particularly describe the invention with reference to the example application to destruction of waste matter.

[0002] This invention relates particularly but not exclusively to treatment of waste products resulting from chemical treatment, chemical conversion and the like. These products often contain highly toxic directly physiologically active or carcinogenic substances. By way of example, such products can include per- or polychlorinated and per- or polyfluorinated aliphatic or aromatic substances such as chlorophenols, dioxins and furans. In addition to their toxicity, these compounds often exhibit high chemical and thermal resistance.

[0003] Waste matter destruction is becoming a problem of great magnitude throughout the world. Two methods of removing contaminated material have become established, namely land fill and high temperature combustion techniques.

[0004] In the land fill technique, which generally only applies to solids, the toxic matter is not destroyed, but is simply stored in dumps. At best the dumps are designed to prevent contamination of ground water by waste matter deposited therein. This technique is not suited to some areas, for example, areas in which there is an ongoing danger of leakage, seepage or the like.

[0005] In the high temperature combustion technique, the generally attainable temperatures, for example up to 1500°C, are insufficient to destroy all the toxic substances. The most thermally stable harmful substances are thus delivered into the atmosphere. Further the combustion process can promote the formation of additional dioxins and furans which are then also delivered into the atmosphere.

[0006] Thus there are disadvantages associated with each of the techniques described above.

[0007] US-A-4644877 discloses a pyrolytic waste destruction system in which waste material is fed to a plasma burner and exits via cylindrical member into a reaction vessel forming a reaction chamber. Waste products exit chamber via outlet openings for quenching in spray ring. The exit chamber is for cooling the pyrolysed waste material to form recombined products.

[0008] According to a first aspect of this invention a thermal decomposition process includes the steps of forming a plasma within a pyrolyser, injecting material to be treated as a fine spray and/or a gas into said plasma, moving said material as a stream through said pyrolyser in a direction towards an exit end of the pyrolyser, maintaining said material at a high temperature during said material stream movement so that substantially complete pyrolysis of said material is achieved and recombination of unwanted by-products is substantially prevented, moving said material stream through said

exit end at a temperature above that at which said recombination will occur, and subjecting said material stream to rapid quenching at or adjacent said exit end and before the temperature of that material stream falls to a level at which recombination to said unwanted by-products will occur.

[0009] In one form of the process, the quenched material is subjected to an environment in which residual toxic compounds are adsorbed on a solid carrier substance so as to be thereby capable of separation from the main body of the material. It is preferred that the solid carrier substance referred to above is particulate carbon, and it is further preferred that the carbon is formed by the treatment of the waste material in the pyrolyser.

[0010] The material to be treated may be in the form of a liquid which is atomised on introduction to the pyrolyser. Alternatively, the material may be in a particulate solid form or in the form of a gas.

[0011] It is preferred that the pyrolyser includes a high energy electrothermal plasma into which the atomised material is injected so as to result in dissociation of the molecules of which the material is composed. The speed at which such dissociation occurs is governed, at least in part, by the temperature of the plasma. It is further preferred that the material emerges from the plasma arc as a stream which passes through a hot zone within which the temperature of the material is maintained at a sufficiently high level to encourage continuation of the pyrolysis which is commenced within the plasma. That may be achieved in a number of ways as hereinafter described. Residence time within the hot zone may be determined as appropriate to increase the probability that there is complete dissociation of all molecules within the material stream. The longer the time for which a particular material is subjected to heating, the greater the likelihood of decomposing compounds exhibiting high thermal resistance. Generally the higher the temperature, the greater will be the speed at which decomposition is accomplished.

[0012] The material stream is cooled by being subjected to rapid quenching in a cooling zone after leaving the hot zone, and the speed of quenching is preferably such as to prevent, or at least minimise, recombination of the dissociated ions.

[0013] Residual toxic compounds which are separated from the material stream by absorption or adsorption on particulate carbon as previously described, may be destroyed by subjecting the particulate carbon to appropriate further treatment.

[0014] In a preferred form of the process, the aforementioned hot zone is defined by a tube (hereinafter called the flight tube) through which the material stream travels between the plasma arc and the cooling zone. The material stream preferably enters that tube immediately upon emerging from the plasma arc. The dimensions and construction of the flight tube can have an influence on the efficiency of the process as hereinafter

discussed.

[0015] As described above, the pyrolysis of material such as waste material may result in production of carbon particles as soot or activated carbon, and those particles could influence downstream processing of the material. For example, the particles could block or partially block the flight tube. This will especially be the case where the material to be treated comprises mainly hydrocarbons. However where the material comprises mainly oxygen containing organic compounds, there may not be a problem with excessive carbon particles.

[0016] In one form of the process, oxygen is introduced into the plasma so as to react with carbon particles as may be formed, and thereby produce gaseous carbon compounds with the concomitant evolution of heat. Such addition of oxygen may therefore lower the level of solid carbon within the material stream so as to more easily facilitate downstream processing of that material for example, facilitate passage of the material stream through the flight tube. Furthermore, the liberated heat assists in maintaining the temperature of the material stream suitably high as it passes through the flight tube to resist recombination to form toxic compounds.

[0017] The need to convert solid carbon to gaseous carbon compounds by addition of oxygen to the process material may be eliminated, or at least reduced, by the dilution of the material to be processed in an inert carrier liquid which passes through the apparatus without affecting the reaction dynamics. The carrier liquid will have the effect of lowering the percentage by weight of carbon particles in the stream issuing from the plasma. Ideally the amount of inert carrier liquid added will be controlled to reduce the percentage by weight of carbon particles to a level that avoids blockages of equipment without the addition of any oxygen.

[0018] In some circumstances, the level of carbon particles in the material stream issuing from the flight tube may be such as to cause blocking or partially blocking at the cooling zone and/or at some other part of the apparatus following the cooling zone, and that may occur notwithstanding the introduction of oxygen into the plasma as described above. To overcome that problem, in one form of the process, further oxygen is added to the stream issuing from the flight tube so as to react with the carbon particles and lower the level of particles within the material stream. The reaction of the oxygen with the carbon is exothermic which assists in maintaining the temperature of the material stream suitably high until actual quenching of the stream takes place. The high temperatures tend to resist recombination of ions to form toxic compounds. It is preferred that a sharp temperature gradient be effectively provided at the cooling zone.

[0019] The cooled material may be exposed to an alkaline environment for encouraging the adsorption of any acidic residual toxic compounds on the carrier substance, for example carbon particles. Thus, toxic com-

pounds which escape pyrolysis, or which are formed by recombination following pyrolysis, can be isolated on the carbon particles, and those particles may be separated from the remainder of the processed material by any suitable means. By way of example, that separation may be achieved through filtration.

[0020] The separated carbon particles, with toxic compounds adsorbed thereon, may be subjected to further treatment to decompose the toxic compounds. For example, the particles may be subjected to further treatment which leads to the toxic compounds being desorbed into a liquid which is then recirculated through the process.

[0021] Alternatively, the carbon particles may be disposed of by landfill. The procedure adopted in any circumstance will generally depend on the level of toxic compounds on the carbon particles.

[0022] According to a second aspect of this invention a thermal decomposition apparatus includes a pyrolyser having means for generating a plasma arc and passage means for containing plasma beyond the region of said arc, material introducing means located at or adjacent the region of said arc and being operative to introduce material into said pyrolyser as a fine spray and/or as a gas, and quenching means located at or adjacent an exit end of said pyrolyser, wherein said pyrolyser is operative to maintain said introduced material at a high temperature so that substantially complete pyrolysis of said material is achieved and recombination of unwanted by-products is substantially prevented during movement of said material through said passage means to the exit end of said pyrolyser and said quenching means is operative rapidly to quench said material emerging from said exit end before the temperature of that emerging material falls to a level at which recombination to said unwanted by-products will occur, and wherein said passage means provides for control of a boundary layer of said material for ensuring a substantially consistent temperature for the material across said passage means.

[0023] Embodiments of the invention are described in detail in the following passages of the specification which refer to the accompanying drawings. The drawings, however, are merely illustrative of how the invention might be put into effect, so that the specific form and arrangement of the various features as shown is not to be understood as limiting on the invention.

[0024] In the drawings:

Figure 1 is a flow diagram representing one form of the process according to the invention.

Figure 2 is a diagrammatic sectional view through one form of pyrolyser for use in a process as represented by Figure 1.

Figure 3 is a semi-diagrammatic cross-sectional view of one form of flight tube suitable for use in the apparatus shown by Figure 2.

Figure 4 is a semi-diagrammatic cross-sectional

view of another form of flight tube suitable for use in the apparatus of Figure 2.

Figure 5 is a diagrammatic view of apparatus in accordance with one embodiment of the invention.

[0025] In Figure 1 the line 1 represents the path of the material to be treated as it is introduced into the pyrolyser 2. The material may be introduced into the pyrolyser 2 in any suitable form, but it is preferred that it be in the form of a fine spray of liquid and/or solid particles, or a gas, or a combination of such a fine spray and a gas. It is further preferred that the material be injected into the pyrolyser 2 under pressure.

[0026] In the event that the material is moved along the path 1 as a stream of liquid, the stream of liquid may be atomised at or immediately preceding the point of injection into the pyrolyser 2, and any suitable nozzle or other means may be used for that purpose. Preferably, the liquid droplets resulting from the atomisation have a diameter of 100 micrometer or less. In particular, the liquid droplets need to be sufficiently small to enable complete pyrolysis. If they are too large, the surface of the droplets may merely char under the conditions existing within the pyrolyser 2.

[0027] If the material entering the pyrolyser 2 is in the form of or includes a spray of solid particles, each of those particles is preferably of a suitably small size for the reason given above. A particle size of 100 micrometer or less will generally be satisfactory.

[0028] The pyrolyser 2 includes means 3 for generating a plasma arc 4 so as to enable production of a high energy electrothermal plasma. The pyrolyser 2 also includes a hot zone 6 immediately following the arc generating means 3 and which receives the material stream 5 emerging from the arc generating means 3.

[0029] It is preferred that the plasma gas 7 is argon or an argon mixture as that produces an inert plasma atmosphere in which the pyrolysis takes place. The arc generating means 3 may, for example, be a plasma torch the same as or similar to that disclosed by PCT Patent Application AU89/00396. In that regard, the temperature within the plasma may typically be in the region 10,000°C to 15,000°C. Alternatively, other types of plasma such as a steam plasma may also be used.

[0030] The direction in which the material to be treated is introduced into the plasma arc 4 may be selected according to preference or circumstances. By way of example, the direction may be generally parallel to the line of the arc 4, or generally transverse thereto, but the later is usually preferred.

[0031] It is preferred that the region of the pyrolyser 2 at which the material to be treated is introduced into the plasma, is maintained at a suitably high temperature, for example, a temperature of 1,000°C or preferably higher. The material may be injected directly into the core of the plasma arc 4, or at least close to the downstream attachment 8 of the arc 4. If direct injection is not possible, the surfaces of the torch 3 in the region of

material introduction may be heated to maintain a temperature of a suitably high level.

[0032] Figure 2 provides a clearer indication of the preferred location of the point 9 at which material to be treated is introduced into the pyrolyser 2. The particular torch 3 which is shown in Figure 2, and which forms part of the pyrolyser 2, includes a cathode 10 and two anodes 11 and 12 separated by a bank 13 of spacers. The anode 11 functions as a start-up anode for initiating the arc 4, and once generated the arc 4 is then extended so that its downstream attachment 8 is at the anode 12. Other forms of torches could be adopted.

[0033] In the particular arrangement shown in Figure 2, material to be treated is injected into the torch passage 14 at or adjacent the location of the arc attachment 8. The direction of that injection is generally transverse to the longitudinal axis of the passage 14 as that facilitates injection into the core of the arc 4.

[0034] The molecules which make-up the injected material are caused to dissociate under the influence of the high temperatures prevailing within the plasma, and the material thereby undergoes pyrolysis, or at least substantial pyrolysis. The material emerges from the plasma arc 4 as a stream 5 which is directed into and through the hot zone 6. The stream of material 5 is primarily a gas having associated therewith particles of solid carbon in the form of soot.

[0035] In the particular arrangement shown, the hot zone 6 is formed by an elongate hollow tube which will be hereinafter referred to as the flight tube. The tube 6 in effect forms an extension or continuation of the torch passage 14, and the dimensions of the tube 6 will be selected to suit particular requirements and circumstances. It is a basic function of the tube 6 to provide containment of the material stream 5 in an environment which promotes continuation of the pyrolysis process. That is, it may happen that pyrolysis of the material is not completed within the torch 3, and the function of the tube 6 is to provide an extension of the environment within which pyrolysis takes place. In particular, the tube 6 extends the residence time of the material within an appropriate high temperature environment and thereby optimises the possibility that complete pyrolysis will be achieved.

[0036] In one arrangement which has operated satisfactorily, the flight tube is slender and has a diameter to length ratio of about 2 in 25. In any particular circumstances however, the length of the tube may be selected so as to achieve a suitable residence time of the processed material within the tube and any suitable diameter to length ratio may be adopted. The nature of the toxic compounds within the material to be treated will influence the determination of an appropriate residence time within the tube 6.

[0037] An important consideration in the design of the tube 6 is the need to maintain the processed material at as high a temperature as possible along the length of the tube, as that assists in preventing undesir-

able recombination reactions. In that regard, the temperature of the stream 5 entering the tube 6 may be above 3,500°C and the temperature of the stream exiting the tube 6 may be 1,200°C, or thereabouts.

[0038] The fluid flow boundary layer of the material stream which contacts the surrounding surface of the tube 6 will tend to cool because of that contact. Accordingly the tube 6 may be designed in such a way as to enable control of the boundary layer so that it is kept as thin as possible. In particular, it is desirable that the temperature of the material stream is substantially consistent throughout that stream as it emerges from the exit end 15 of the pyrolyser 2.

[0039] One approach to the foregoing is shown diagrammatically in Figure 3. The inner surface of the flight tube 6 shown in Figure 3 is provided with a series of lips 16 which tend to deflect the boundary layer of the material stream 5 back towards the axial center of that stream. The resulting turbulence inhibits the formation of a distinct cool boundary layer, and there is continual mixing of the boundary layer with the inner relatively hot body of the material stream such that a substantially consistent temperature is maintained across the width of the stream.

[0040] Figure 4 illustrates another approach in which the tube 6 has a lining 17 which is capable of withstanding high temperatures, and particularly temperatures above 1,000°C. By way of example, the lining 17 may be composed of a ceramic material. If desired, such an arrangement may be modified by introducing an external source of heat to the lining 17 at an appropriate location, such as adjacent to the exit end 15 of the pyrolyser 2. Also, the body 18 of the tube 6 which surrounds the lining 17 may be cooled by water (for example) entering at the inlet 19 and exiting at the outlet 20. Similar cooling may be desirable in other forms of the tube 6, including that shown in Figure 3.

[0041] As previously mentioned, the material stream 5 issuing from the torch 3 will contain carbon particles. If the level of carbon particles is relatively high, there may be a danger of the carbon blocking the tube 6. In order to alleviate that problem, a stream of oxygen may be fed into the pyrolyser 2 for converting some of the carbon particles to gaseous carbon compounds. In the particular example shown in Figures 1 and 2, the oxygen is fed into the torch 3 at a location 21 adjacent the point 9 at which the material to be treated is introduced. Other arrangements are clearly possible.

[0042] The reaction of carbon and oxygen is exothermic and a considerable amount of heat is liberated. This heat assists in maintaining the temperature of the material stream at a suitably high level to encourage continuation of the pyrolysis and to resist recombination of dissociated ions and simple compounds to form undesirable compounds.

[0043] In one possible arrangement, the tube 6 may include a graphite lining. In such a case, it may be important to control the stream of oxygen entering at 21,

so as to maintain an oxygen deficient atmosphere within the tube 6. By way of example, the ratio of oxygen to carbon may be maintained at 30% below stoichiometric levels. If such an atmosphere is not maintained some oxygen may react with the carbon of the tube lining, thereby eating away the lining.

[0044] An oxygen deficient atmosphere will also tend to reduce the combination of dissociated ions to form undesirable oxygen containing compounds.

[0045] The material stream 5 passing out of the exit end 15 of the pyrolyser 2 is subjected to quenching in a cooling zone 22. In the arrangement shown, the material is then, and/or subsequently, subjected to an environment as hereinafter described in which residual toxic organic compounds are adsorbed on a particulate carrier. By way of example, the carrier substance may be provided by the unreacted carbon particles remaining within the material stream 5.

[0046] The level of carbon particles in the material stream 5 passing out of the exit end 15 may, for example, be 1% by weight, or greater. Such a level of carbon may cause clogging or blocking of components of the processing apparatus which follow the pyrolyser 2. Consequently, in some circumstances it may be desirable to further reduce the carbon content by the introduction of a further stream 23 of oxygen to convert some of the remaining carbon particles to gaseous carbon products. Preferably, the carbon content of the material stream entering the cooling zone 22 is in the order of 0.5% by weight.

[0047] The introduction of the further oxygen stream 23 may have another effect. That is, the heat generated by the reaction of that oxygen with carbon may assist in maintaining the material stream 5 at a suitably high temperature right up until actual quenching takes place. In that regard, it is desirable that the temperature of the material stream 5 just prior to quenching be at least 1,500°C, and it is preferred that the temperature be in order of 1,800°C to 2,000°C.

[0048] As mentioned above, the higher temperatures resist recombination of dissociated ions to form toxic compounds, for example dioxins. Generally, it is thought desirable to maintain the temperature in the material stream 5 up to the time of quenching, at a level which is sufficiently high to avoid the possibility of CO in the stream 5 reforming into CO₂.

[0049] As indicated above, the introduction of the further stream 23 of oxygen will not be necessary in all applications of the invention.

[0050] In the particular configuration shown the cooling zone 22 includes a bank of sprays 24 arranged to produce a cool barrier 25 through which the material stream 5 must pass. That is, the stream 5 is confined to a passage 26 which is completely filled at the location of the sprays 24 by the barrier 25. The arrangement is such that quenching of the material stream is complete, and that as a result there is a very sudden sharp drop in the temperature of the material. In the example shown,

the passage 26 is formed as an extension of the passage through the tube 6.

[0051] The cooled material issuing from the cooling zone 22 may be passed into and through a scrubber 27 as shown. The pH of the scrubber 27 will generally be alkaline for removing acidic compounds from the material received. The carbon particles within that material may be dispersed within a body 28 of the alkaline scrubber liquor so that acidic organic compounds are encouraged to be adsorbed on the carbon particles. The optimum process parameters such as pH and temperature of the scrubber, liquor which are required to achieve maximum toxic organic compound adsorption, may be determined by routine experimentation.

[0052] In one particular example the scrubber liquor is a sodium hydroxide solution, but other types of liquor may be used. Furthermore, in the configuration illustrated by Figure 1, the same liquor may be used in the quench sprays 24 and the scrubber sprays 29. For that purpose, a pump 30 may operate to draw liquor from the liquor body 28 to feed the sprays 24 and 29. The line 31 in Figure 1 represents the supply of liquor to the scrubber 27, and the line 32 represents the withdrawal of spent liquor from the scrubber 27.

[0053] The carbon particles may be separated from the scrubber liquor by means of a simple filtration process, which is indicated in Figure 1 by the block 33. That filtration may be carried out on a continuous basis or on a batch basis.

[0054] The toxic organic compounds adsorbed on the carbon particles may be separated from the carbon particles by a desorption process which is represented by the block 34 in Figure 1. That is, the adsorption process effected in the scrubber 27 is reversed. The compounds are typically desorbed in water which can be recycled through the process as part of the material input 1.

[0055] In the particular construction shown by Figure 2 the scrubber 27 has a rectangular configuration and is substantially larger than the tube which forms the cooling zone 22. A plurality of scrubber sprays 29 are located in the operatively upper region of the scrubber 27 for directing scrubber liquor as a fine spray or mist. The direction of that spray or mist is preferably downwards.

[0056] The apparatus may include an explosion vent 35 as shown in Figure 5, to vent the system in the event of the build-up of an explosive gaseous mixture. This is an important safety feature to reduce the danger of explosion. The explosion vent is of known form and construction. In the example shown, the vent 35 is located adjacent the scrubber 27.

[0057] The material which has remained in the gaseous form and which has not been scrubbed from the gas in the scrubber 27, may be passed to atmosphere by way of a stack 36 shown in Figure 5. The stack 36 may, for example, include a number of stack sprays 37 which operate to remove any remaining traces of gase-

ous compounds having an affinity for an aqueous alkaline environment. In the particular arrangement shown, the stack sprays 37 are supplied with liquor by way of the pump 30.

[0058] The pyrolyser 2 specifically, and the entire apparatus more generally, forms a very compact unit which lends itself to on-site use. For example the apparatus can be integrated into an existing process so that there is no nett production of toxic waste. This is a major advantage as the transportation of toxic substances is hazardous.

[0059] A unique characteristic of the process described is the deliberate retention of particulate carbon within the stream of material and the control of the process conditions such that the carbon particles act as a carrier substance for toxic organic compounds which have survived the pyrolysis phase of the process. That is, the organic compounds which survived the processing steps preceding the quenching process, are effectively captured by attachment or adsorption on the carbon particles. The surviving organic compounds are thereby captured in a manner which facilitates convenient disposal or alternatively subsequent processing as considered appropriate, depending on the level of toxic organic compounds. That is contrary to the accepted practice of inhibiting carbon formation in existing toxic compound destruction processes.

[0060] Analysis of material emerging from the scrubber has revealed that the level of destruction of toxic products in the process steps preceding the scrubber, is in the order of 99.9999%. Further treatment of the separated carbon particles enables the level of destruction to be increased beyond 99.9999%. A process according to the invention is useful for the effective destruction of a wide variety of toxic products, including chlorophenols and dioxins. The process is robust and safe.

[0061] Various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the invention as defined by the appended claims.

Claims

1. A thermal decomposition process including the steps of forming a plasma within a pyrolyser (1), injecting material (1) to be treated as a fine spray and/or a gas into said plasma, moving said material as a stream (5) through said pyrolyser in a direction towards an exit end (26) of the pyrolyser, maintaining said material at a high temperature during said material stream movement so that substantially complete pyrolysis of said material is achieved and recombination of unwanted by-products is substantially prevented, moving said material stream through said exit end at a temperature above that at which said recombination will occur, and subjecting

- said material stream to rapid quenching (22, 24, 25) at or adjacent said exit end (26) and before the temperature of that material stream falls to a level at which recombination to said unwanted by-products will occur.
2. A process according to claim 1, wherein the temperature of said material stream immediately prior to said quenching is such that CO in said material stream has not commenced to reform into CO₂.
 3. A process according to claim 1 or claim 2, wherein said plasma is formed by use of a gas which is a noble gas.
 4. A process according to claim 3, wherein said gas is argon or an argon mixture.
 5. A process according to any one of claims 1 to 4, wherein said plasma is generated by an electric arc (4) created between two electrodes (10, 12), and said material (1) is injected into said plasma at a location adjacent the attachment (8) of said arc to the electrode (12) which forms the anode.
 6. A process according to any one of claims 1 to 4, wherein said plasma is generated by an electric arc (4) created between two electrodes (10, 12), and said material is injected into the core of said arc.
 7. A process according to claim 5 or claim 6, wherein said material is injected in a direction extending generally transverse to the direction in which said arc extends between said electrodes.
 8. A process according to any one of claims 1 to 7, wherein said material is injected into said pyrolyser in the form of atomized liquid.
 9. A process according to claim 8, wherein the size of the liquid droplets forming said atomized liquid is 100 microns or less.
 10. A process according to any one of claims 1 to 7, wherein said material is injected into said pyrolyser in the form of solid particles.
 11. A process according to claim 10, wherein the size of each said particle is 100 micrometer or less.
 12. A process according to any one of claims 1 to 11, wherein oxygen (21) is introduced into said pyrolyser at or adjacent the location of said material injection.
 13. A process according to any one of claims 1 to 11, wherein a partially oxidizing atmosphere exists within said pyrolyser.
 14. A process according to any one of claims 1 to 13, wherein said pyrolyser includes a plasma torch (2) and a hot zone extending between that torch and the location at which said quenching takes place.
 15. A process according to claim 14, wherein said hot zone is formed within a tube (6), and a boundary layer of said material which contacts the surrounding surface of said tube is controlled so that the material within said material stream is at a substantially consistent temperature at the time it is subjected to said quenching.
 16. A process according to any one of claims 1 to 13, wherein said pyrolyser includes a tube (6) through which said material passes towards said exit end, and a boundary layer of said material which contacts the surrounding surface of said tube is controlled so that the material within said material stream is at a substantially consistent temperature at the time it is subjected to said quenching.
 17. A process according to claim 15 or claim 16, wherein said boundary layer is controlled by inducing turbulent flow in said boundary layer.
 18. A process according to claim 15 or claim 16, wherein said boundary layer is controlled by deflecting it inwards towards the centre of said material stream.
 19. A process according to claim 15 or claim 16, wherein said boundary layer is controlled by maintaining a suitably high temperature in a wall of said tube which forms said surrounding surface.
 20. A process according to any preceding claim, wherein said quenched material is subjected to an environment in which residual toxic compounds are absorbed on a solid carrier substance, and said substance is thereafter separated from said material.
 21. A process according to claim 20, wherein said carrier substance is particulate carbon.
 22. A process according to claim 21, wherein said carbon particles are formed by said pyrolysis.
 23. A process according to claim 21 or claim 22, wherein said toxic compounds are desorbed from said carrier substance.
 24. A process according to any preceding claim, wherein the temperature of the material just prior to quenching is at least 1500°C.
 25. A process according to claim 24, wherein the tem-

perature of the material just prior to quenching is at least 1800°C.

26. Thermal decomposition apparatus including, a pyrolyser (2) having means (10, 11, 12) for generating a plasma arc (4) and passage means (6) for containing plasma beyond the region of said arc, material introducing means (1) located at or adjacent the region of said arc and being operative to introduce material into said pyrolyser as a fine spray and/or as a gas, and quenching means (22, 24, 25) located at or adjacent an exit end of said pyrolyser, wherein said pyrolyser is operative to maintain said introduced material at a high temperature so that substantially complete pyrolysis of said material is achieved and recombination of unwanted by-products is substantially prevented during movement of said material through said passage means (6) to the exit end of said pyrolyser and said quenching means is operative rapidly to quench said material (5) emerging from said exit end before the temperature of that emerging material falls to a level at which recombination to said unwanted by-products will occur, and wherein said passage means (6) provides for control of a boundary layer of said material for ensuring a substantially consistent temperature for the material across said passage means. 5 10 15 20 25
27. Apparatus according to claim 26, wherein said generating means includes a plasma torch having a passage (14) therethrough, and said material introducing means (1) is arranged to introduce material into said passage in a direction which is substantially transverse to the longitudinal direction of said passage. 30 35
28. Apparatus according to claim 27, wherein said plasma containing means includes a tube (6) which forms a continuation of said plasma torch passage. 40
29. Apparatus according to any one of claims 26 to 28, wherein said generating means includes a cathode (10) and an anode (12) arranged in spaced relationship from said cathode, and said material introducing means (1) is located at said anode. 45
30. Apparatus according to any one of claims 26 to 29, wherein said quenching means (24, 25) is located at said exit end and is operable to produce a cool barrier through which material exiting from said pyrolyser must pass. 50
31. Apparatus according to any one of claims 26 to 30, wherein said passage means includes means (16) for inducing turbulent flow in a boundary layer of the material stream. 55

32. Apparatus according to claim 31, wherein the turbulent flow inducing means comprises a series of lips (16) for deflecting a boundary layer of the material stream towards the axial centre of the passage means (6) for mixing the material stream.

33. Apparatus according to any one of claims 26 to 30, wherein the boundary layer is controlled by means maintaining a suitably high temperature in a wall of said passage means (6).

34. Apparatus according to claim 33, wherein the means for maintaining a suitably high temperature comprises a lining of material.

35. Apparatus according to claim 34, wherein said lining of material is heated.

Patentansprüche

1. Thermischer Zersetzungsprozeß mit den Schritten: Erzeugen eines Plasmas innerhalb einer Pyrolyseeinrichtung (1), Injizieren eines zu behandelnden Stoffes (1) als feinen Sprühnebel und/oder Gas in das Plasma, Bewegen des Stoffes als Strom (5) durch die Pyrolyseeinrichtung in Richtung auf ein Austrittsende (26) der Pyrolyseeinrichtung, Halten des Stoffes bei einer hohen Temperatur während der Bewegung des Stoffstroms, so daß eine im wesentlichen vollständige Pyrolyse des Stoffes erreicht wird und eine Rekombination unerwünschter Nebenprodukte im wesentlichen verhindert wird, Bewegen des Stoffstroms durch das Austrittsende bei einer Temperatur oberhalb derjenigen, bei der die Rekombination stattfindet, und schnelles Abschrecken (22, 24, 25) des Stoffstroms bei oder nahe dem Austrittsende (26) und bevor die Temperatur des Stoffstroms auf einen Pegel fällt, bei dem eine Rekombination zu unerwünschten Nebenprodukten stattfindet.
2. Prozeß nach Anspruch 1, worin die Temperatur des Stoffstroms unmittelbar vor dem Abschrecken derart ist, daß CO im Stoffstrom nicht begonnen hat, sich in CO₂ umzuformen.
3. Prozeß nach Anspruch 1 oder Anspruch 2, worin das Plasma durch Verwendung eines Gases gebildet wird, das ein Edelgas ist.
4. Prozeß nach Anspruch 3, worin das Gas Argon oder ein Argongemisch ist.
5. Prozeß nach einem der Ansprüche 1 bis 4, worin das Plasma durch einen zwischen zwei Elektroden (10, 12) erzeugten Lichtbogen (4) erzeugt wird und der Stoff (1) in das Plasma an einer Stelle injiziert wird, die dem Anschluß (8) des Bogens an der

Elektrode (12) benachbart ist, die die Anode bildet.

6. Prozeß nach einem der Ansprüche 1 bis 4, worin das Plasma durch einen zwischen zwei Elektroden (10, 12) erzeugten Lichtbogen (4) erzeugt wird und der Stoff in den Kern des Bogens injiziert wird. 5
7. Prozeß nach Anspruch 5 oder Anspruch 6, worin der Stoff in einer Richtung injiziert wird, die im wesentlichen quer zu der Richtung verläuft, in der sich der Bogen zwischen den Elektroden erstreckt. 10
8. Prozeß nach einem der Ansprüche 1 bis 7, worin der Stoff in Form einer zerstäubten Flüssigkeit in die Pyrolyseeinrichtung injiziert wird. 15
9. Prozeß nach Anspruch 8, worin die Größe der zerstäubten Flüssigkeit bildenden Flüssigkeitströpfchen 100 Mikrometer oder weniger beträgt. 20
10. Prozeß nach einem der Ansprüche 1 bis 7, worin der Stoff in Form fester Teilchen in die Pyrolyseeinrichtung injiziert wird. 25
11. Prozeß nach Anspruch 10, worin die Größe jedes Teilchens 100 Mikrometer oder weniger beträgt. 30
12. Prozeß nach einem der Ansprüche 1 bis 11, worin Sauerstoff (21) an der Stelle der Stoffinjektion oder dieser benachbart in die Pyrolyseeinrichtung eingeführt wird. 35
13. Prozeß nach einem der Ansprüche 1 bis 11, worin innerhalb der Pyrolyseeinrichtung eine teilweise oxidierende Atmosphäre existiert. 40
14. Prozeß nach einem der Ansprüche 1 bis 13, worin die Pyrolyseeinrichtung einen Plasmabrenner (2) und eine heiße Zone enthält, die sich zwischen dem Brenner und der Stelle erstreckt, an der das Abschrecken stattfindet. 45
15. Prozeß nach Anspruch 14, worin die heiße Zone innerhalb eines Rohres (6) ausgebildet ist und eine Grenzschicht des Stoffes, die die umgebende Oberfläche des Rohres berührt, so gesteuert wird, daß der Stoff innerhalb des Stoffstroms zu der Zeit, zu der er dem Abschrecken unterzogen wird, bei einer im wesentlichen gleichmäßigen Temperatur liegt. 50
16. Prozeß nach einem der Ansprüche 1 bis 13, worin die Pyrolyseeinrichtung ein Rohr (6) enthält, durch das der Stoff zum Austrittsende gelangt, und eine Grenzschicht des Stoffes, die die umgebende Oberfläche des Rohres berührt, so gesteuert wird, daß der Stoff innerhalb des Stoffstroms zu der Zeit, zu der er dem Abschrecken unterzogen wird, bei

einer im wesentlichen gleichmäßigen Temperatur liegt.

17. Prozeß nach Anspruch 15 oder Anspruch 16, worin die Grenzschicht durch Induzieren eines turbulenten Stroms in der Grenzschicht gesteuert wird.
18. Prozeß nach Anspruch 15 oder Anspruch 16, worin die Grenzschicht gesteuert wird, indem sie einwärts in Richtung auf die Mitte des Stoffstroms abgelenkt wird.
19. Prozeß nach Anspruch 15 oder Anspruch 16, worin die Grenzschicht gesteuert wird, indem eine geeignete hohe Temperatur in einer Wand des Rohres aufrechterhalten wird, die die umgebende Oberfläche bildet.
20. Prozeß nach einem der vorhergehenden Ansprüche, worin der abgeschreckte Stoff einer Umgebung ausgesetzt wird, in der restliche toxische Verbindungen auf einer festen Trägersubstanz absorbiert werden und die Substanz danach vom Stoff getrennt wird.
21. Prozeß nach Anspruch 20, worin die Trägersubstanz teilchenförmiger Kohlenstoff ist.
22. Prozeß nach Anspruch 21, worin die Kohlenstoffteilchen durch die Pyrolyse gebildet werden.
23. Prozeß nach Anspruch 21 oder Anspruch 22, worin die toxischen Verbindungen von der Trägersubstanz desorbiert werden.
24. Prozeß nach einem der vorhergehenden Ansprüche, worin die Temperatur des Stoffes kurz vor einem Abschrecken mindestens 1500°C beträgt.
25. Prozeß nach Anspruch 24, worin die Temperatur des Stoffes kurz vor einem Abschrecken bei mindestens 1800°C liegt.
26. Thermisches Zersetzungsgerät, umfassend eine Pyrolyseeinrichtung (2) mit einer Einrichtung (10, 11, 12) zum Erzeugen eines Plasmabogens (4) und einer Durchgangseinrichtung (6) zum Aufnehmen eines Plasmas jenseits des Bereichs des Bogens, einer stoffeinführenden Einrichtung (1), die beim Bereich des Bogens oder diesem benachbart liegt und betrieben werden kann, um einen Stoff in die Pyrolyseeinrichtung als feinen Sprühnebel und/oder Gas einzuführen, und einer Abschreckeinrichtung (22, 24, 25), die bei einem Austrittsende der Pyrolyseeinrichtung oder diesem benachbart liegt, worin die Pyrolyseeinrichtung betrieben werden kann, um den eingeführten Stoff bei einer hohen Temperatur zu halten, so daß eine im

wesentlichen vollständige Pyrolyse des Stoffes erreicht wird und eine Rekombination unerwünschter Nebenprodukte im wesentlichen verhindert wird während einer Bewegung des Stoffes durch die Durchgangseinrichtung (6) zum Austrittsende der Pyrolyseeinrichtung und die Abschreckeinrichtung betrieben werden kann, um den aus dem Austrittsende austretenden Stoff (5) schnell abzuschrecken, bevor die Temperatur des austretenden Stoffes auf einen Pegel fällt, bei dem eine Rekombination zu den unerwünschten Nebenprodukten stattfindet, und worin die Durchgangseinrichtung (6) für eine Steuerung einer Grenzschicht des Stoffes sorgt, um eine im wesentlichen gleichmäßige Temperatur für den Stoff über die Durchgangseinrichtung sicherzustellen.

27. Gerät nach Anspruch 26, worin die Erzeugungseinrichtung einen Plasmabrenner mit einem Durchgang (14) enthält und die stoffeinführende Einrichtung (1) angeordnet ist, um einen Stoff in den Durchgang in einer Richtung einzuführen, die im wesentlichen quer zur Längsrichtung des Durchgangs verläuft.

28. Gerät nach Anspruch 27, worin die Plasma enthaltende Einrichtung ein Rohr (6) enthält, das eine Fortsetzung des Plasmabrennerdurchgangs bildet.

29. Gerät nach einem der Ansprüche 26 bis 28, worin die Erzeugungseinrichtung eine Kathode (10) und eine von der Kathode in einer beabstandeten Beziehung angeordnete Anode (12) enthält und die stoffeinführende Einrichtung (1) bei der Anode liegt.

30. Gerät nach einem der Ansprüche 26 bis 29, worin die Abschreckeinrichtung (24, 25) am Austrittsende liegt und betreibbar ist, um eine kühle Barriere zu erzeugen, durch die der aus der Pyrolyseeinrichtung austretende Stoff gelangen muß.

31. Gerät nach einem der Ansprüche 26 bis 30, worin die Durchgangseinrichtung eine Einrichtung (16) zum Induzieren eines turbulenten Stroms in einer Grenzschicht des Stoffstroms enthält.

32. Gerät nach Anspruch 31, worin die einen turbulenten Strom induzierende Einrichtung eine Reihe Lippen (16) aufweist, um eine Grenzschicht des Stoffstroms in Richtung auf die axiale Mitte der Durchgangseinrichtung (6) zum Mischen des Stoffstroms abzulenken.

33. Gerät nach einem der Ansprüche 26 bis 30, worin die Grenzschicht durch eine Einrichtung gesteuert wird, die eine geeignet hohe Temperatur in einer Wand der Durchgangseinrichtung (6) aufrechterhält.

34. Gerät nach Anspruch 33, worin die Einrichtung zum Aufrechterhalten einer geeignet hohen Temperatur eine Stoffauskleidung aufweist.

35. Gerät nach Anspruch 34, worin die Stoffauskleidung geheizt wird.

Revendications

1. Un procédé de décomposition thermique, comprenant les étapes de former un plasma à l'intérieur d'un pyrolyseur (1), d'injecter le matériau (1) devant être traité sous la forme d'une fine pulvérisation et/ou un gaz dans ledit plasma, de transférer ledit déplacement de matériau sous la forme d'un courant (5) à travers ledit pyrolyseur dans une direction vers une extrémité de sortie (26) du pyrolyseur, de maintenir ledit matériau à une température élevée pendant le déplacement du courant de matériau de sorte qu'une pyrolyse essentiellement complète dudit matériau soit achevée et la recombinaison des sous-produits non souhaitée soit essentiellement évitée, de transférer ledit courant de matériau à travers ladite extrémité de sortie à une température au-dessus de celle pour laquelle ladite recombinaison se produit, et de soumettre ledit courant de matériau à une trempe rapide (22, 24, 25) au niveau de ou adjacent à ladite sortie d'extrémité (26) et avant que la température de ce courant de matériau ne tombe à un niveau pour lequel une recombinaison desdits sous-produits non désirés se produirait.

2. Un procédé selon la revendication 1, dans lequel la température dudit courant de matériau, immédiatement avant ladite trempe, est telle que le CO dans ledit courant de matériau n'a pas commencé à se transformer en CO₂.

3. Un procédé selon la revendication 1 ou la revendication 2, dans lequel ledit plasma est formé par l'utilisation d'un gaz qui est un gaz noble.

4. Un procédé selon la revendication 3, dans lequel ledit gaz est de l'argon ou un mélange à base d'argon.

5. Un procédé selon l'une quelconque des revendications 1 à 4, dans lequel ledit plasma est produit par un arc électrique (4) créé entre deux électrodes (10, 12), et ledit matériau (1) est injecté dans ledit plasma en un endroit adjacent à la fixation (8) dudit arc à l'électrode (12) qui forme l'anode.

6. Un procédé selon l'une quelconque des revendications 1 à 4, dans lequel ledit plasma est produit par un arc électrique (4) créé entre deux électrodes (10, 12), et ledit matériau est injecté dans l'âme

dudit arc.

7. Un procédé selon la revendication 5 ou la revendication 6, dans lequel ledit matériau est injecté dans une direction s'étendant, en général, transversalement dans la direction dans laquelle ledit arc s'étend entre lesdites électrodes. 5
8. Un procédé selon l'une quelconque des revendications 1 à 7, dans lequel ledit matériau est injecté dans ledit pyrolyseur sous la forme d'un liquide atomisé. 10
9. Un procédé selon la revendication 8, dans lequel la dimension des gouttelettes de liquide formant ledit liquide atomisé est de 100 microns ou moins. 15
10. Un procédé selon l'une quelconque des revendications 1 à 7, dans lequel ledit matériau est injecté dans le produit pyrolyseur sous la forme de particules solides. 20
11. Un procédé selon la revendication 10, dans lequel la dimension de chacune desdites particules est de 100 microns ou moins. 25
12. Un procédé selon l'une quelconque des revendications 1 à 11, dans lequel l'oxygène (21) est introduit dans ledit pyrolyseur au niveau de, ou adjacent à l'endroit de ladite injection du matériau. 30
13. Un procédé selon l'une quelconque des revendications 1 à 11, dans lequel une atmosphère partiellement oxydante existe à l'intérieur dudit pyrolyseur. 35
14. Un procédé selon l'une quelconque des revendications 1 à 13, dans lequel ledit pyrolyseur comprend un chalumeau à plasma (2) et une zone chaude s'étendant entre ce chalumeau et l'endroit au niveau duquel ladite trempe se produit. 40
15. Un procédé selon la revendication 14, dans lequel ladite zone chaude est formée à l'intérieur d'un tube (6), et une couche limite dudit matériau qui vient en contact avec la surface enveloppante dudit tube est contrôlée de sorte que le matériau à l'intérieur dudit courant de matériau est à une température sensiblement stable au moment où il est soumis à ladite trempe. 45
16. Un procédé selon l'une quelconque des revendications 1 à 13, dans lequel ledit pyrolyseur comporte un tube (6) à travers lequel ledit matériau passe vers ladite extrémité de sortie, et une couche limite dudit matériau qui vient en contact avec la surface environnante dudit tube est contrôlée de façon que le matériau à l'intérieur dudit courant de courant est à une température essentiellement stable au 50

moment où il est soumis à ladite trempe.

17. Un procédé selon la revendication 15 ou la revendication 16, dans lequel ladite couche limite est contrôlée en provoquant un écoulement turbulent à l'intérieur de ladite couche limite.
18. Un procédé selon la revendication 15 ou la revendication 16, dans lequel ladite couche limite est contrôlée en la déviant à l'intérieur vers le centre dudit courant de matériau.
19. Un procédé selon la revendication 15 ou la revendication 16, dans lequel ladite couche limite est contrôlée en maintenant une température élevée, dans une mesure appropriée, dans une paroi dudit tube qui forme ladite surface enveloppante.
20. Un procédé selon l'une quelconque des revendications précédentes, dans lequel ledit matériau trempé est soumis à un environnement dans lequel les composés toxiques résiduels sont absorbés sur une substance support solide, et ladite substance est, par la suite, séparée dudit matériau.
21. Un procédé selon la revendication 20, dans lequel ladite substance support est du carbone particulaire.
22. Un procédé selon la revendication 21, dans lequel les particules de carbone sont formées par ladite pyrolyse.
23. Un procédé selon la revendication 21 ou 22, dans lequel lesdits composés toxiques sont désorbés à partir de ladite substance support.
24. Un procédé selon l'une des revendications précédentes, dans lequel la température du matériau juste avant la trempe est d'au moins 1500°C.
25. Un procédé selon la revendication 24, dans lequel la température du matériau juste avant la trempe est d'au moins 1800°C.
26. Un appareil de décomposition thermique comportant un pyrolyseur (2) possédant des moyens (10, 11, 12) pour produire un arc de plasma (4) et des moyens de passage (6) pour maintenir le plasma au-delà de la région dudit arc, un moyen d'introduction du matériau (1) situé au niveau de ou adjacent à la région dudit arc et étant apte à fonctionner pour introduire le matériau dans ledit pyrolyseur sous la forme d'une fine pulvérisation et/ou sous la forme d'un gaz, et des moyens de trempe (22, 24, 25) situés au niveau de ou adjacents à une extrémité de sortie dudit pyrolyseur, dans lequel ledit pyrolyseur est apte à fonctionner pour maintenir ledit 55

matériau introduit à une température élevée de façon qu'une pyrolyse essentiellement complète du matériau soit achevée et qu'une recombinaison des sous-produits non souhaités soit essentiellement évitée pendant le mouvement dudit matériau à travers lesdits moyens de passage (6) vers l'extrémité de sortie dudit pyrolyseur et que lesdits moyens de trempe soient aptes à fonctionner rapidement pour tremper ledit matériau (5) qui sort de ladite extrémité de sortie avant que la température de ce matériau sortant ne tombe à un niveau auquel une recombinaison en sous-produits non souhaités se produira, et dans lequel lesdits moyens de passage (6) procurent un contrôle de la couche limite dudit matériau pour assurer une température essentiellement stable de ce matériau à travers lesdits moyens de passage.

27. Appareil selon la revendication 26, dans lequel lesdits moyens de production comportent un chalumeau à plasma ayant un passage (14) traversant, et lesdits moyens d'introduction du matériau (1) sont agencés pour introduire le matériau dans ledit passage dans une direction qui est essentiellement transversale à la direction longitudinale dudit passage.
28. Appareil selon la revendication 27, dans lequel lesdits moyens renfermant le plasma comporte un tube (6) qui forme un prolongement dudit passage du chalumeau à plasma.
29. Appareil selon l'une quelconque des revendications 26 à 28, dans lequel lesdits moyens de production comportent une cathode (10) et une anode (12) agencées en relation espacée de ladite cathode, et lesdits moyens d'introduction du matériau (1) sont situés au niveau de ladite anode.
30. Appareil selon l'une quelconque des revendications 26 à 29, dans lequel lesdits moyens de trempe (24, 25) sont situés au niveau de l'extrémité de sortie et sont aptes à fonctionner pour produire une barrière de refroidissement à travers laquelle le matériau sortant dudit pyrolyseur doit passer.
31. Appareil selon l'une quelconque des revendications 26 à 30, dans lequel lesdits moyens de passage comportent des moyens (16) pour provoquer un écoulement turbulent dans une couche limite du courant de matériau.
32. Appareil selon la revendication 31, dans lequel les moyens pour provoquer l'écoulement turbulent comprennent une série de lèvres (16), déviant une couche limite du courant de matériau vers le centre axial des moyens de passage (6) pour mélanger le courant de matériau.

33. Appareil selon l'une quelconque des revendications 26 à 30, dans lequel la couche limite est contrôlée par des moyens maintenant une température élevée, dans une mesure appropriée, dans une paroi desdits moyens de passage (6).
34. Appareil selon l'une quelconque des revendications 33, dans lequel les moyens pour maintenir une température élevée, de façon appropriée, comportent une garniture de matériau.
35. Appareil selon la revendication 34, dans lequel ladite garniture de matériau est chauffée.

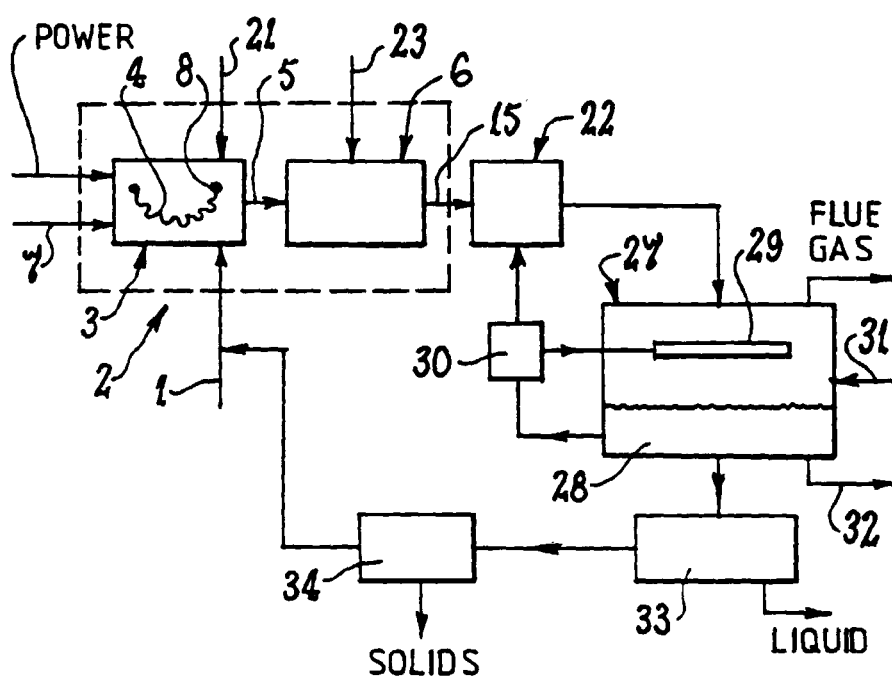
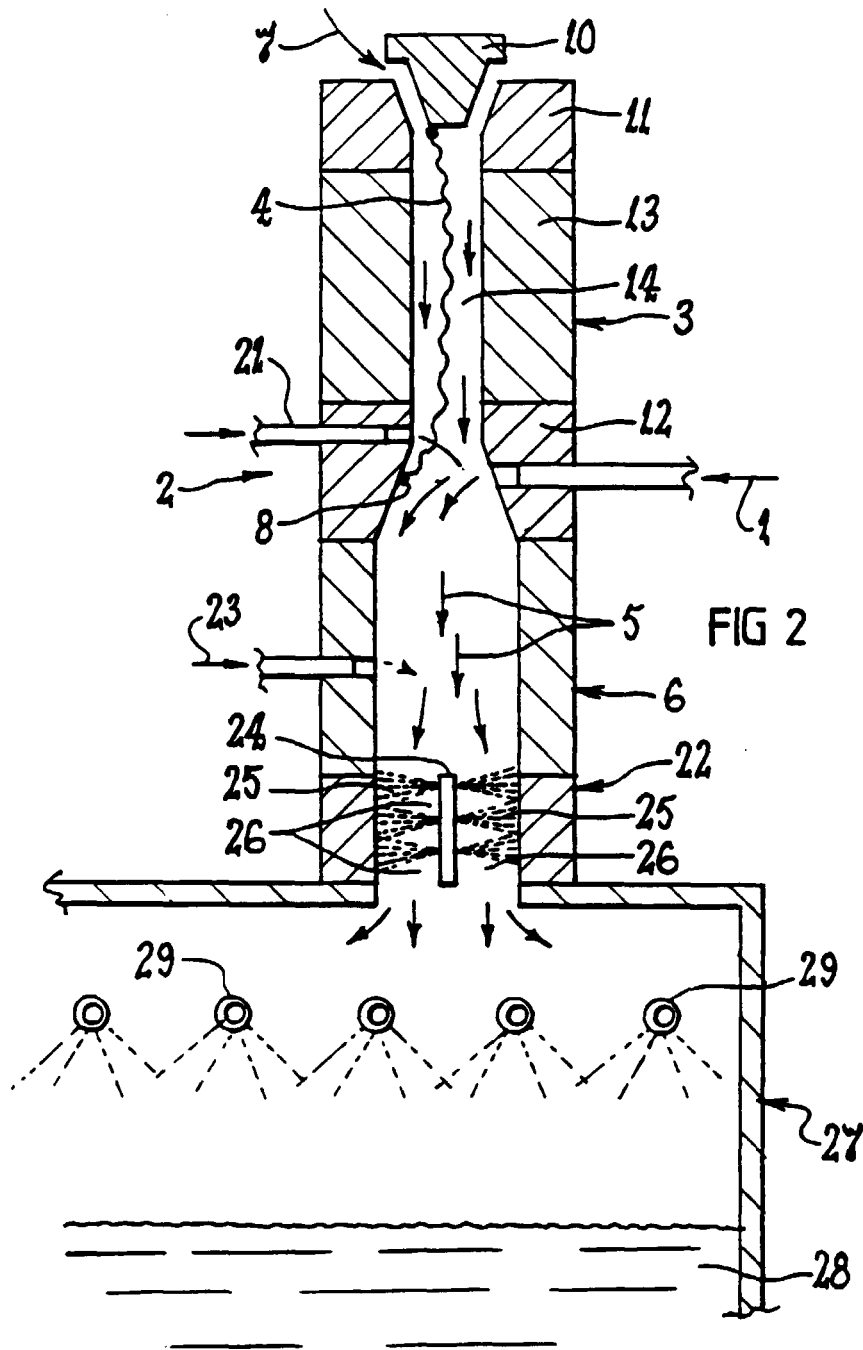
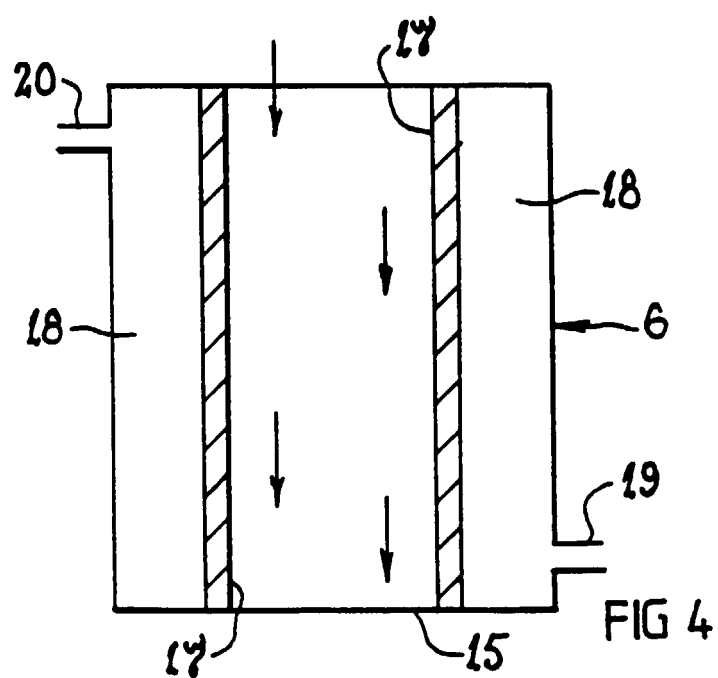
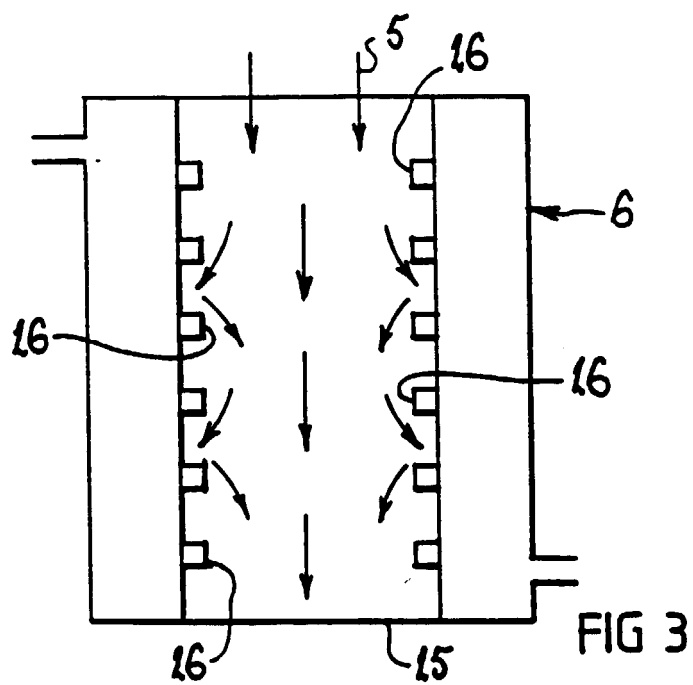


FIG 1





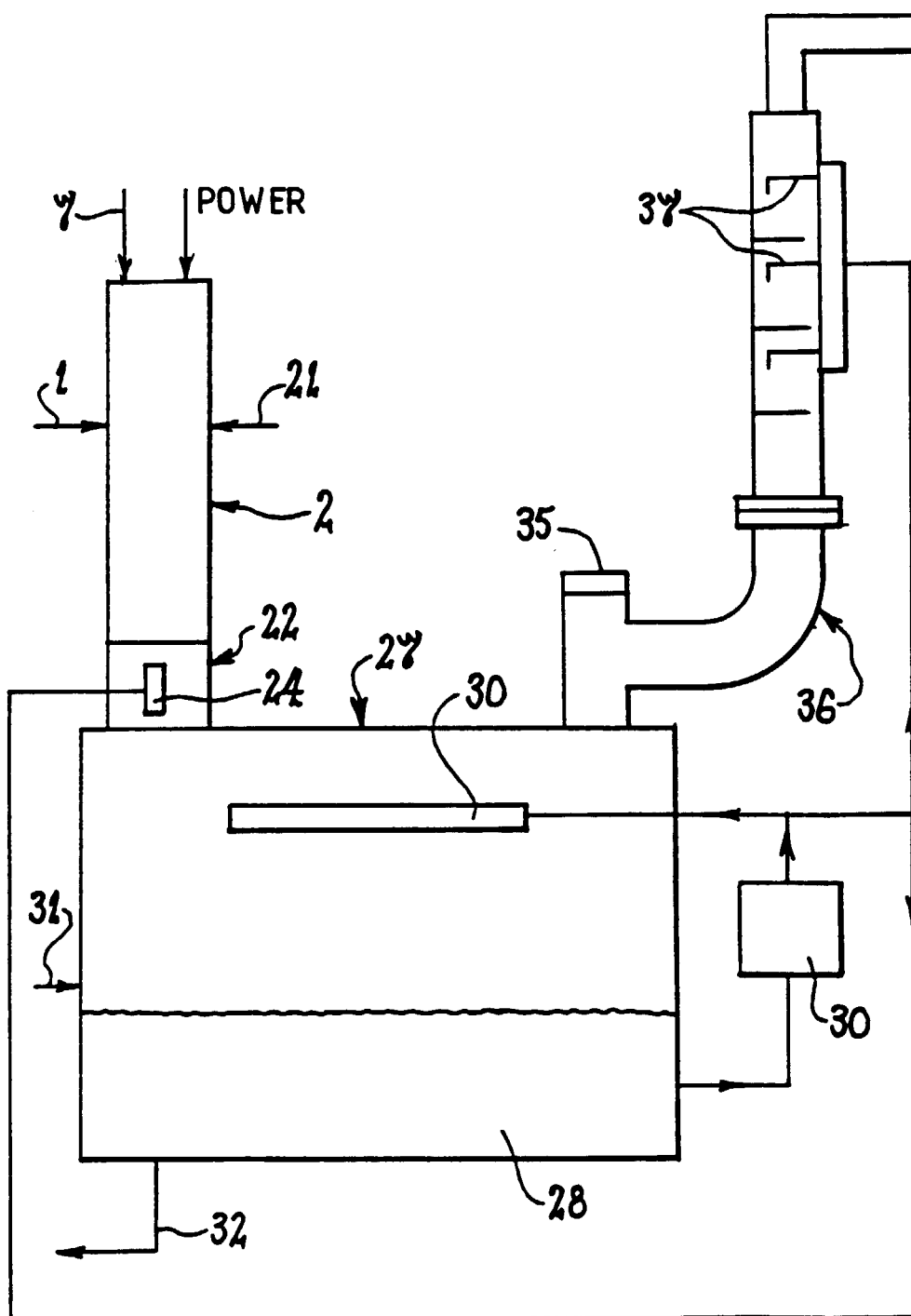


FIG 5