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(54) **Plant for treating refuse by pyrolysis and for producing energy by means of said treatment**

(57) A plant for treating solid and/or liquid refuse comprises an environment or reactor (1) in which pyrolysis of the refuse takes place, said reactor (1) being connected to and fed by refuse feed means (9), means (13) for feeding a combustion support and means (8, 8V) for feeding an oxidizing agent. The refuse feed means (9) comprise micro-disintegrating means (76, 80) and pre-gasification means (2, 5) to enable the liquid refuse to be transformed into the gaseous phase and the solid refuse to be transformed into the liquid and/or gaseous phase before their entry into the reactor (1) and before their pyrolysis, this latter hence taking place within the entire refuse mass fed into the reactor (1). Means are provided to recover inert products of the pyrolysis and to recover gas produced by this latter.

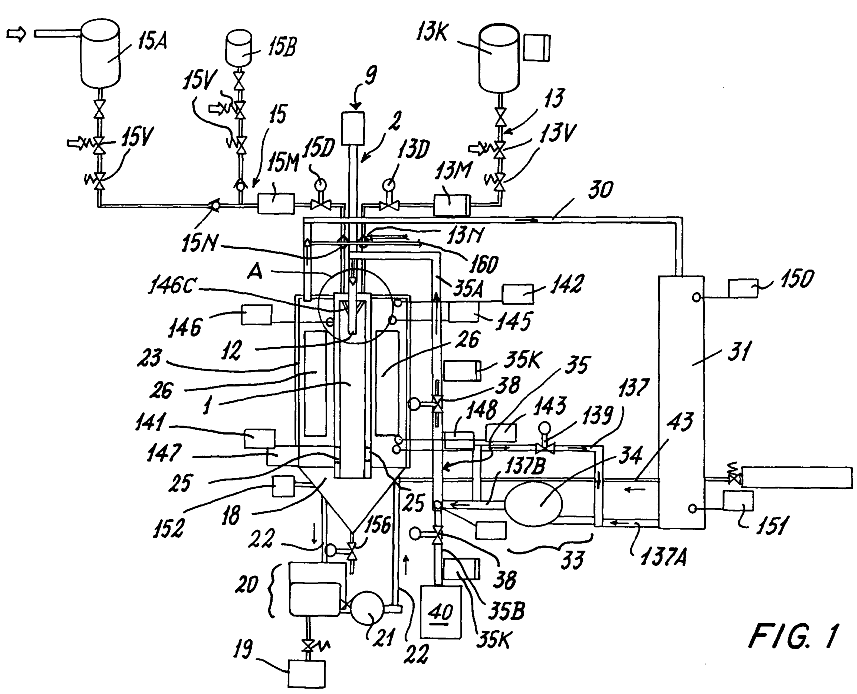

FIG. 1

EP 1 296 095 A2

Description

[0001] The present invention relates to a plant for treating solid and/or liquid refuse by pyrolysis in accordance with the introduction to the main claim. The invention also relates to a method for treating refuse within the aforesaid plant, in accordance with the corresponding independent claim. Refuse disposal has become a well known and increasingly urgent problem in particular in the more developed countries. Also well known is the need to recover energy from the refuse treatment and disposal process to make it increasingly attractive economically.

[0002] Two main refuse treatment methods (in addition to classical dumping) are known: that by which the refuse is fed to an incinerator and that by which the refuse is treated by a pyrolytic process. In the first process and in the relative plant in which it is implemented, relatively low temperatures are generated together with large air volumes leading to the formation of noxious gases which have to be suitably retained and/or treated before being discharged to atmosphere. This results in very high plant costs together with problems of environmental impact caused by products which cannot be eliminated. Moreover the refuse combustion temperature does not always enable the refuse fed into the incinerator to be completely destroyed.

[0003] With regard to the pyrolytic process, this is implemented within a plant in which the refuse is fed in such dimensions as not to enable it to be completely treated. In this respect, the pyrolysis which occurs in such plants intervenes only on the surface of the refuse mass because of the refuse compactness and dimensions. Consequently the process under examination does not enable correct and complete refuse disposal to be obtained on termination. For this reason, a pyrolysis plant does not enable a large quantity of energy to be generated by the process; consequently the plant itself and the implementation of the pyrolytic process represent costs which are difficult to recover within an acceptable time.

[0004] An object of the present invention is to provide a plant for treating refuse by pyrolysis which enables the refuse to be completely demolished, with the formation generally of CO_2 and H_2, this latter being able to produce clean electrical energy which can be used to self-sustain the plant or for other ecological uses such as motor traction using hydrogen motors, and fuel cells.

[0005] Another object is to provide a plant of the aforesaid type which enables valuable gases, such as pure H_2 and CO_2, to be produced and recovered for other uses external to the plant.

[0006] A further object is to provide a plant of acceptable maintenance and operating costs.

[0007] A further object is to provide a plant of the stated type which has virtually no environmental impact.

[0008] These and further objects are attained by a plant in accordance with the accompanying corresponding claims.

[0009] Another object is to provide a method for treating refuse by means of the plant of the invention, said method being of high efficiency and acceptable implementation cost.

[0010] This object is attained by a method in accordance with the accompanying corresponding claims.

[0011] The present invention will be more apparent from the accompanying drawing, which is provided by way of non-limiting example and in which:

Figure 1 shows a simplified scheme of the plant according to the invention;
Figure 2 is a schematic view of a part of the plant of Figure 1;
Figure 3 is a schematic view of a portion of the plant part of Figure 2;
Figure 4 is a schematic view of another part of the plant of Figure 1;
Figure 5 is a partly sectional plan view of one embodiment of the plant portion of Figure 3;
Figure 6 is a section on the line 6-6 of Figure 5;
Figure 7 shows one embodiment of the part indicated by A in Figure 1 and parts 2 and 5 of Figure 2;
Figure 8 is an enlarged view of the part indicated by B in Figure 7; and
Figure 9 is a section on the line 9-9 of Figure 8.

[0012] The plant of the present invention is based on the high temperature pyrolysis of organic substances (substances containing essentially carbon and hydrogen) for the purpose of producing very pure H_2 gas for use as fuel in appliances such as steam-producing boilers combined with steam turbines, gas turbines combined with micro-steam turbines or fuel cells combined with micro-steam turbines; all aimed at the production of electrical energy which, besides powering energy consumers of the cycle, produce an excess to be utilized for uses external to the plant.

[0013] The essential concepts on which this technology is based are those of a clean and correct pyrolysis developed at high temperature and controlled with the aid of regulating and control systems preferably of microprocessor type. The purpose of this is to obtain the final production of a gas of almost total molecular hydrogen composition (H_2) for use in fuel cells, with initial utilization in gas turbines with condensation heat exchangers to produce electrical energy and, where necessary and usable, hot water for domestic or heating purposes, with final condensation of pure water to be used within the cycle itself and of which any excess can be used either as pure (distilled) water or in mixture with potable water derived from desalination plants. The inert part present in the liquid or solid refuse is melted at pyrolytic temperature, vitrified by cooling in water and extracted as perfectly inert material usable for example as filling material in road covering mixtures (in view of its particle size, hardness and degree of inertness).

[0014] In its most general form (see Figures 1-4), the plant of the invention comprises a reactor 1 in which pyrolysis takes place of refuse fed into said reactor 1 via a feed line 2. This refuse can be solid and/or liquid. This latter originates from a tank 3 connected via a pump or other feed means to a member 5 into which there converge the liquid refuse, the solid refuse from a plant portion 7 shown schematically in Figure 3 and constructionally in Figures 5 and 6 and described hereinafter, high pressure and high temperature steam metered and regulated by a measurement and control member 8V comprising a pneumatic control valve and a flowmeter (not shown), and the powder PR. The liquid refuse is evaporated by the steam entering the member 5.

[0015] Within the plant portion 7 the refuse is micro-disintegrated to dimensions enabling it to be easily liquefied or pre-sublimed by the thermal energy of the steam fed into the portion 7 by metering via a pneumatic control valve and quantified by a flowmeter under the control of an operating and control unit (described hereinafter) which handles and controls the plant operation. The steam is fed into the portion 7 by a feed unit 8 in determined proportions based on the type of refuse being treated. The refuse treated in this manner reaches the member 5, where it is vaporized and/or sublimed by the feed of steam through the measurement and control member 8V, and is further heated by steam circulating in counter-current along an external jacket 10 of the line 2 see Figure 7), in order to evaporate the liquid and create substantial gasification of all the refuse fed into the line 2. In this respect, gasification means the complete evaporation of the liquid refuse or the refuse previously liquefied within the plant portion 7 and the complete sublimation of the micro-disintegrated solid refuse (that which does not have a liquid phase) within the steam present in the line 2. The members directly or functionally connected to the line 2 define a plant pretreatment portion for the refuse 9.

[0016] The refuse hence arrives at the reactor 1, at a nozzle 12 to which there also arrive an oxygen feed line 13 and a feed line 15 connected to a hydrogen tank 15A forming part of the plant or, alternatively, a tank 15B of any fuel such as liquefied gas (LPG) or methane. The fuel 15B serves only for start-up until hydrogen is produced for feed into the tank 15A; the hydrogen in excess of that required for sustaining pyrolysis at the nozzle 12 of the reactor 1 (H_2 and O_2 stoichiometric combustion) feeds the electrical energy production line either comprising a boiler and steam turbine, or a gas turbine and steam micro-turbine, or fuel cells and a micro-steam turbine (not shown). For some types of liquid and/or solid refuse, when pyrolysis has commenced there is no further need for fuel (H_2), pyrolysis being sustained by the pure oxygen alone, which utilizes part of the hydrogen already developed at the nozzle 12 of the refuse 1. At the nozzle 12 (shown in detail in Figures 7-9 which will be described hereinafter), the refuse undergoes pyrolysis at very high temperature, leading to the cracking of the organic molecules into simple elementary molecules CO, CO_2, H_2 etc. of the refuse; the inert fraction produced by the reaction falls by gravity into the lower part 18 of the reactor 1 and is vitrified in water, from whence it is collected in a tank 19 after passing through a filter 20 by the action of a pump 21. This latter withdraws through a line 22 any solid refuse plus the vitrification and wash water from the part 18 of the reactor 1, it feeds them through the filter 20 where they separate, and returns the solid-free water to the part 18 of the reactor 1. The level of the wash and vitrification water is continuously monitored and made up to a level determined by a level indicator 152 by water from a plant water recovery line 43.

[0017] The reactor 1 is contained within an outer enclosure 23 provided with an interspace through which hot water circulates to recover heat from the enclosure; the reactor 1 communicates with the outer enclosure 23 through apertures 25 provided below the reactor 1 and adjusted in their degree of opening by an electromechanical device 156 controlled by a regulation and control system 147 operating on the basis of the pressure in the enclosure 23. The enclosure contains heat exchangers, for example of serpentine coil type 26, arranged in several internal columns and with one column sandwiched within the enclosure 23 to produce high pressure superheated steam by the passage along its surface of hot gas from the reactor. A part of this steam is fed to the feed unit 8 and to the member 8V of Figure 3 and Figure 2, to the jacket 10 of the line 2, and to a catalysis line 160. As described hereinafter, this steam is metered and measured by the pneumatic control valve and flowmeter (regulated and controlled by the plant operating and control unit). The steam is also fed to a cooling line 35A for the nozzle 12, again metered and controlled by a valve and flowmeter controlled by the control unit, and finally the excess steam is fed via a valve and flowmeter controlled by the control unit, to a heat exchanger 243 of a gas separation line 40 shown in Figure 4. The gas produced by the reactor is extracted from the enclosure 23 through a line 30 and transferred to a heat exchanger 31, for example of tube bundle type.

[0018] Within this heat exchanger, the gas undergoes violent cooling and is fed to a gas recycle plant portion 33 in which a variable-throughput motor-driven fan 34 is present to feed this pyrolysis gas to a line 35. This has two branches 35A and 35B into which there are connected flowmeters 35K and metering valves 38, operated and controlled by the regulator and control unit to control the quantity of pyrolysis-produced gas to be recirculated through the reactor 1 and that to be fed to the aforesaid line 40 of Figure 4 for the gas enrichment and separation stages; for example, the valves 38 are of the pneumatic control valve type. The two branches of the line 35 are connected respectively to the outside of the nozzle 12 (to create thereat a turbulence between the arriving fluids) and to the gas separation line 40 shown in Figure 4. From this line, via various heat exchangers and reactors described hereinafter, carbon dioxide (CO_2), molecular hydrogen (H_2) and water are obtained, this latter being returned, mixed with the various wash and cooling water streams, to the plant via the said line 43. Any powder material present in the fluid of line 40 is recycled and reaches the member 5 (where it is indicated by PR) and to the reactor 1 where it is inerted and vitrified.

[0019] The refuse pretreatment portion 9 will now be analyzed in greater detail. As stated, this latter comprises the portion 7 where the solid refuse is micro-disintegrated and mixed with the high pressure, high temperature steam from the serpentine coils 26. With reference to Figures 3, 5 and 6, the portion 7 is shown comprising a container 70 in which the solid refuse is collected. This latter is fed into a hopper 71 in which a mixer 72 is positioned, driven by its own electric motor 73. The hopper lowerly presents a metering screw 74 (shown schematically in Figure 3 as coaxial with the hopper, but in reality positioned as shown in Figure 5) terminating with a frusto-conical end 75 by means of which the refuse R is pressed and directed towards a first disintegrating unit 76 provided with a disintegrating member 77 (for example defined by moving disintegration blades) and a conveying member 78 defined for example by a screw. The member 78 caries the refuse (via a frusto-conical part 76A), subjected to first disintegration, towards a second disintegrating unit 80 provided with a disintegrating member 81 and a conveying member 82 totally similar to the said members 77 and 78. The conveying member 82 carries the now finely disintegrated (or rather micro-disintegrated) refuse towards a dispensing zone 84 of the second disintegrating unit where a container 85 is present having its longitudinal axis W perpendicular to the axis T of the unit 80 and acting as an "overflow" member or dispensing member for the micro-disintegrated refuse. This container comprises a piston 87 positioned above its contents and pressed onto the refuse with a pressure obtained by feeding air above the piston via a suitable conduit 80. An adjustable bleed member 91 is positioned at the closed top 92 of the container 85 (where the conduit 90 is connected) and enables the pressure in the container to be regulated. In the example, the piston 87 is associated with a rod 95 emerging from the top 92 and cooperating with a proximity sensor 96 carried by a support 97 (position measurer or encoder) fixed to said top. On the basis of the relative position of the rod 95, this sensor generates a proximity signal directed towards a control unit 100 (data processing unit for the management and control of all the processes described in the present text), preferably a microprocessor member and a programmed logic interface, which controls the entire plant and operates each moving member (motor, valve, flow meters, or other) present therein. On the basis of the position of the rod (or of the piston 87 within the container 85), the unit 100 controls the speed of the geared motors 73 and of the motors 74A of the screw 74, 78A of the member 78 and 82A of the member 82 of the plant portion 7. In this manner the quantity of refuse fed to the reactor 1 is controlled to prevent an excess of refuse in this latter.

[0020] The dispensing zone 84 is connected, by a conduit 101 leaving a frusto-conical part 80A, to a further conveying member 102 inserted into a transfer unit 103 (provided with its own geared motor 102A also controlled by the unit 100) which is connected to the refuse reception unit 5 to which it transfers the micro-disintegrated refuse liquefied or pre-sublimed by the steam fed into the disintegrating unit 76. It should be noted that vacuum (indicated by X in Figure 3) is preferably applied to the first disintegrating unit 76. This is achieved by a usual pump (not shown) and by the formation of "plugging" at the exit from this unit and in the end 75 of the hopper 71 caused by the amassing of refuse within these parts. Steam is injected into the two cones 75 and 76A of Figure 5 via conduits 8W by the feed unit 8 shown in Figure 3 in order to soften and heat the refuse, to cause it to flow and facilitate micro-disintegration.

[0021] The refuse in the section 7 is also heated by steam flowing through a double wall positioned about the screws 78, 82, 102, and by the hot water within the interspace of the screw 74.

[0022] As stated, the liquid refuse also reaches the member 5 through a conduit 110 into which the pump 4, a normally closed pneumatic safety valve 111, a non-return valve 112 and a flowmeter 111k are connected, this latter, by means of the unit 100, controlling the throughput of the pump 4 under the control of an electronic inverter (not shown). Another unidirectional valve 113 is also present in the line 2 to prevent refuse returning from the reactor 1 to the member 5 because of any excess pressure present in said reactor. Along this line there are also provided a normally closed spring-operated safety valve 114 for any overpressure, a metering valve 115 operated and controlled by the unit 100, and temperature and pressure measuring devices for the fluid in the line 2, indicated by 118 and 119 respectively.

[0023] As stated, the line 2 also presents a jacket 10 through which steam circulates originating from the serpentine coil 16. This steam raises the temperature of the fluid (steam with evaporated liquid refuse and micro-disintegrated solid refuse) flowing through the line 2 towards the reactor 1. As this line is defined by several segments joined together by flanges F, by-pass lines 120 for the jacket 10 are present around these flanges.

[0024] Figure 7 also shows a conduit 8Z connected to the member 8V to feed steam into the line 2 (fully described hereinbefore) and conduits 122 for feeding steam into the jacket 10.

[0025] The line 2 is connected to a multiple pipe 125 presenting a central section S1 and concentric annular sections S2, S3 and S4, visible in Figures 7 and 8. These sections are connected respectively to the line 2, to the oxygen feed line 13, to the hydrogen or fuel feed line 15, to a line 201 carrying cooling steam for the nozzle 12 and to the branch 35A of the line 35 which carries recirculation gas to the reactor 1. This gas advantageously creates turbulence between the other fluids leaving the nozzle 12 to hence enable complete pyrolysis of the refuse fed into the reactor. About the outer wall 126 of the pipe 125 an annular chamber 127 is present through which the gas produced by the said pyrolysis recirculates.

[0026] It should be noted that in correspondence with the terminal parts of the various sections of the pipe 125 defined by cylindrical walls 125A, 125B, 125C and by the outer wall 126, very fine apertures 128 are present through which the various fluids originating from the sections S2, S3 and S4 pass, even though the section S2 is directly connected to the section S1 via a series of apertures 130 provided at the end of the pipe 125A for feeding O_2 directly into the pre-gasified refuse. These apertures 130 are preferably inclined and made with interchangeable nozzles having different diameter holes such as to cause the oxygen to emerge at sonic velocity to create turbulence within the fluid containing the pre-gasified refuse; those apertures 128, carrying a part of the O_2, the fuel and the cooling steam to the nozzle 12, are formed, for example, as cuts having right or left helixes such as to widen the flame and create maximum turbulence within the inner part of the nozzle 12 where pyrolysis at very temperature occurs.

[0027] Moreover as shown in Figures 7 and 8, the (main) section S1 through which the fluid containing the "gasified" refuse arrives can be closed by a closure member 131 movable within that section. Said member 131 is carried by an end 132A of a rod 132, the other end 132B of which is subjected to an actuator member 133 (pneumatic, mechanical or electrical) in order to be able to move in a guided manner within the section S1. That end 132A carries a disc 134 on which there acts a spring 135 inserted into a chamber 136 within which the disc moves, between this latter and a chamber end face 136A through which the rod 132 passes. The closure member can cooperate with a projecting edge 200 formed in the interior of the section S1.

[0028] The nozzle 12 presents fins 12A which separate it from the wall 1A of the reactor 1 and enable the gas produced by the refuse pyrolysis to be recirculated.

[0029] The various sections S2, S3 and S4 are connected to the respective lines 13, 15 and 201 as shown in Figure 7.

[0030] The lines 13 and 15 are conceptually similar: both are connected, for example, to gas tanks (respectively oxygen (gaseous or liquid) 13K and hydrogen 15K or methane gas or liquefied propane gas 15B), and present a plurality of normally closed valves 13V and 15V, non-return valves 13N and 15N, metering valves 13D and 15D and mass flowmeters 13M and 15M. Alternatively, the pure oxygen is obtained from a self-contained unit fed with electrical energy produced by the plant.

[0031] Other valve members, as stated, are present in the branches 35A and 35B of the line 35, and a control valve 139 in a bypass line 137 in the plant portion 33 which connects together the entry conduit 137A to the fan 34 and the exit conduit 137B therefrom. This conduit 137B is connected to the line 35, at its connection point there being a pressure sensor 140. Similar pressure sensors are present in the lower part of the reactor 1 (sensor 141), in the upper part of the enclosure 23 (sensor 142) and in the lower part thereof (sensor 143).

[0032] Temperature sensors are also present, specifically 145 and 146 positioned respectively in the upper part of the enclosure 23 and of the reactor 1, 147 and 148 positioned in the lower part of this latter and of the enclosure 23, and 146C for measuring the temperature of the enclosure itself. Other temperature sensors 150 and 151 are positioned at the two ends of the heat exchanger 31.

[0033] All these sensors and valves are controlled by the unit 100.

[0034] The level indicator 152 is connected to the lower part 18 of the reactor 1, to which there is also connected the mechanical linear control actuator 156 which regulates the degree of opening of the passages 25 (controlled by the unit 100).

[0035] As stated, the pyrolysis gas leaving the enclosure 23 passes through the line 30. To this there also arrives catalysis steam from a line 160 (suitably controlled and metered by a control valve and flowmeter controlled by the unit 100), plus the steam from the serpentine coil line 26; hot water passes through an interspace (not shown) of the enclosure 23, present along the wall of the reactor 1, in order to cool this wall.

[0036] Returning to the line 30, as stated this terminates in the heat exchanger 31, at the exit of which the plant portion 33 is located; from the exit of this latter the pyrolysis gas is at least partly fed to the separation line 40 shown in greater detail, but schematically, in Figure 4. With reference to this figure, the line 40 comprises a plurality of catalytic converters 240 (two in Figure 4) connected in series. Their function is to oxidize carbon monoxide to carbon dioxide ($CO \rightarrow CO_2$) present in the gas or fluid originating from the reactor 1, so increasing the temperature of this latter. A filtration unit 241 is present in series with the converters 240, to filter off and retain powder material present in the fluid originating from the reactor; this unit 241 is connected to a recirculation member 242 for the retained powder, and 242A for the metered powder for the pyrolysis, which are returned to the cycle at the member 5 (and indicated by PR in Figure 2).

[0037] The unit 241 is followed by a heat exchanger 243 and then a quenching unit 244 comprising a scrubbing, purification and cooling unit 245 for the pyrolysis gas and a droplet separation unit 246 for recovering the water present in the fluid originating from the reactor. This water is then returned to the reactor 1 via the line 43.

[0038] The line 40 further comprises, downstream of the unit 244, a concentrator 247 comprising, in the example of Figure 4, a unit 248 for enriching the CO_2-H_2 mixture still present in the fluid originating from the unit 244. Carbon dioxide is also absorbed in the unit 248 by a suitable known solvent. Downstream of the unit 248 there is a unit 250 for scrubbing the enriched H_2 gas and removing the residues of the solvent used in the unit 248. The scrubbing water is recycled to the line 43. Gaseous H_2 can hence be obtained from the unit 250 for compression by a compressor 250A into the tank 15A, from which there flows that part fed via the line 15 to pyrolysis and the excess part utilized for various uses, for example for the fuel cells to produce electrical energy for operating the plant, any excess being sold.

[0039] The unit 248 is finally connected to a solvent storage tank 248S via the line 254A. The solvent is recirculated to the unit 248 by a pump or other device 254P via the line 254B, the CO_2-laden solvent returning to the tank 248S via a line 254A; a pump 253P withdraws the CO_2-laden solvent from the tank 248S and feeds it to a stripping column 251 via the line 253A where countercurrent air from a fan 255 passing through a line 256 removes the CO_2 from the solvent and discharges it with the air through the vent 257; the purified solvent returns to the tank 248S via the line 253B.

[0040] The aforedescribed concentrator 247 can alternatively comprise a CO_2-H_2 mixture enrichment unit with mixture compression for separation through a membrane, a unit for freezing the CO_2 and separating it from the residual H_2, then loading it into cylinders for industrial use, and a unit for scrubbing the enriched H_2 gas and removing miscellaneous residues and recycling the water to water make-up, to give virtually pure H_2.

[0041] Hence summarizing, the following are fed to the plant:

a) The raw material (the refuse) which, in the case of solid refuse, must be previously disintegrated; liquid refuse does not require pretreatment.
b) Pure oxygen either obtained from the air by a self-contained unit powered by the electrical energy produced within the plant itself, or taken from an appropriate container.
c) Distilled or demineralized pure water which after start-up originates from the water recovered by condensation in the electrical energy production unit.

[0042] The refuse a) provides the fuel (together with the line 15), the oxygen b) is the combustion support and the water c) is the oxidizing agent.

[0043] The plant provides:

a) Electrical and thermal energy
b) Vitrified inerts
c) Excess pure water
d) Carbon dioxide (CO_2)

[0044] In its primary function, the plant enables solid and liquid refuse of organic origin (almost the whole of existing refuse) to be eliminated (without pollution) while at the same time enabling clean electrical energy to be produced from waste materials. Refuse is eliminated without pollution because the residues are electrical energy, pure water without salts, and vitrified inerts, only carbon dioxide being discharged to atmosphere; in the highest performance case the CO_2 is also recovered, for use in the plastic industries, welding etc.

[0045] The final result in the highest performance case is therefore to transform what is merely refuse for disposal (more or less bulky and noxious refuse) into electrical energy as a clean and renewable source, usable inerts (for example for road coverings) and CO_2 for industrial uses.

[0046] All this is achieved with a plant designed in accordance with high energy physical and chemical relationships and having an original configuration from the technology, operation and management viewpoint.

[0047] The plant of the invention is summarily described hereinafter in terms of its innovative components. The plant as described hence comprises:

1. Unit for feeding the material into the chamber of the high temperature pyrolysis reactor;
2. Unit for producing high temperature, high pressure steam with recovery of thermal energy from the pyrolysis gas;
3. High temperature pyrolysis member with very high performance and nearly stoichiomeric yields;
4. Member for controlling, mixing and creating turbulence of the gases within the pyrolytic process;
5. Member for re-solidifying, vitrifying and separating the inert slag;
6. Converters for converting CO into CO_2;
7. Powder filtration member, powder recycling and metering of powder materials for producing vitrified inerts;
8. Pyrolysis gas cooling and scrubbing unit.
9. Mixture enrichment unit for producing H_2 and separating CO_2.
10. Unit for recycling and metering powder materials for their solidification and for eliminating pollutants from the gas.
11. Unit for producing electrical energy for self consumption and for external feed.
12. Unit for condensing and recovering H_2O for its recycling to the plant and for use of the excess either as distilled water or adding to desalinated water in sea-water desalination plants.
13. Systems and units for producing primary O_2.

[0048] A specific embodiment of the invention has been described. Others are possible while remaining within the scope of the present document.

Claims

1. A plant for treating solid and/or liquid refuse, comprising an environment or reactor (1) in which the refuse (R) is subjected to pyrolysis treatment, said refuse (R) being fed to the reactor (1) by feed means (2), means (19, 40) being provided to recover and/or treat the solid, liquid and gaseous products deriving from said refuse pyrolysis treatment and being connected to said reactor (1), **characterised in that** the feed means (2) comprise micro-disintegrating means (76, 80) and pre-gasifying means (2, 5) for transforming the liquid refuse into the gaseous phase and the solid refuse into the vapour or gaseous phase prior to their introduction into the reactor (1), in order that the total mass of refuse is able to undergo the thermal pyrolysis treatment with its consequent complete demolition.

2. A plant as claimed in claim 1, **characterised in that** the micro-disintegrating and pre-gasifying means comprise a reception member (5) arranged to receive the liquid refuse from a feed conduit (110) and to receive the solid refuse already micro-disintegrated within a plant portion (7) presenting the micro-disintegrating means (76, 80), the reception member also receiving steam at high pressure and high temperature, from said member (5) the refuse being transferred to the reactor (1).

3. A plant as claimed in claim 2, **characterised in that** the micro-disintegrating means comprise at least one disintegrating unit (76, 80) presenting a disintegrating member (77, 81) which receives the refuse mixed with steam fed by a suitable unit (8), a feed member (74, 78), and a conveying member (78, 82) which transfers the micro-disintegrated refuse to an exit provided in a tapered part (76A, 80A).

4. A plant as claimed in claim 3, **characterised in that** the disintegrating member (77, 78) comprises a plurality of movable disintegrating blades.

5. A plant as claimed in claims 2 and 3, **characterised by** comprising at least two disintegrating units (76, 80) connected in cascade, the first (76) receiving the solid refuse to be micro-disintegrated though a screw feeder (74) at which the refuse arrives from a hopper (70) preferably provided with a mixer (72), the second disintegrating unit (80) feeding the micro-disintegrated refuse to the reception member (5).

6. A plant as claimed in claim 5, **characterised in that** between the reception member (5) and the second disintegrating unit (80) there is present a transfer unit (103), these units being mutually perpendicular, the second disintegrating unit (80) also being positioned perpendicular to the first unit (76).

7. A plant as claimed in claim 3, **characterised in that** the disintegrating unit (80) comprises regulator means (85, 87, 95, 96) controlling the flow of micro-disintegrated refuse to the reception member (5).

8. A plant as claimed in claim 3, **characterised in that** the regulator means comprise a container (85) positioned with its longitudinal axis (W) perpendicular to the longitudinal axis (T) of the disintegrating unit (80), means (87, 95, 96) being provided in said container to measure the quantity of refuse which has penetrated into and been collected in the container before its exit from the tapered part (80A) of the disintegrating unit (80) towards the reception member (5), said measurement means (87, 95, 96) being connected to plant control means (100) which on the basis of the quantity of refuse present in the container (85) control the rate of flow of the refuse to the reactor (1) and control each controlled movable member present in the plant to enable the pyrolysis treatment to take pace on the refuse.

9. A plant as claimed in claim 8, **characterised in that** the measurement means are a piston (87) movable within the container (85) under the action of the refuse (R) and against a resistant force, said piston (87) being connected to a rod (95) movable in front of a proximity sensor (96) connected to the plant control means (100).

10. A plant as claimed in claim 9, **characterised in that** the resistant force is a fluid under pressure, preferably air, said pressure being adjustable.

11. A plant as claimed in claim 8, **characterised in that** the plant control means (100) comprise a microprocessor unit.

12. A plant as claimed in claim 3, **characterised in that** the disintegrating unit (76, 80) receives steam at high pressure and high temperature.

13. A plant as claimed in claim 12, **characterised by** comprising a steam feed member (8) connected to the disintegration unit (76, 80).

14. A plant as claimed in claim 3, **characterised in that** vacuum is created in the disintegrating unit (76, 80).

15. A plant as claimed in claim 1, **characterised in that** the reactor (1) is located in a container or enclosure (23) in which heat exchangers (26) are present to produce steam at high temperature and high pressure to be also used in the feed means (2), said heat exchangers being lapped by the gaseous products deriving from the refuse pyrolysis.

16. A plant as claimed in claim 1, **characterised in that**, for feeding the pre-gasified refuse to the reactor (1), the feed means comprise a line (2) connected to the reception member (5) for the pre-gasified and micro-disintegrated refuse.

17. A plant as claimed in claim 16, **characterised in that** the feed line (2) is connected to a high pressure and high temperature steam feed (8V) for gasifying the entry refuse, said line (2) having a perimetral interspace (10) through which steam circulates in counter-current at high pressure and high temperature to enhance the gasification of the refuse.

18. A plant as claimed in claim 16, **characterised in that** the feed line (2) flows into a multiple pipe (125) presenting different sections (S1, S2, S3, S4) flowing into a nozzle (12) and connected respectively to said line (2), to a fuel feed line 15), to a combustion-support feed line (13), to a high pressure and high temperature steam feed line (201) for cooling the nozzle (12), and to a conduit (35A) which recirculates the pyrolytic gas to create turbulence within the fluids leaving the nozzle (12).

19. A plant as claimed in claim 18, **characterised in that** a controlled closure member (131) is present **in that** section (S1) of the multiple pipe (125) connected to the refuse feed line (2) in order to regulate the flow of refuse to the reactor (1) until it interrupts this flow when it cooperates with a seat (200) provided on the wall (125A) defining said section (S1).

20. A plant as claimed in claim 18, **characterised in that** the powdered refuse recycled from other parts of the plant also reach the nozzle (12) from other parts (242, 242D) of the plant, via the conduit (35A).

21. A plant as claimed in claim 18, **characterised in that** the nozzle (12) presents external fins (12A).

22. A plant as claimed in claim 18, **characterised in that** the combustion-support feed line (13) is connected to a source of oxygen (13K).

23. A plant as claimed in claim 18, **characterised in that** the fuel feed line (15) is connected to a tank of hydrogen (15A) or of a fuel gas (methane or LPG) (15B).

24. A plant as claimed in claim 18, **characterised in that** the fuel feed and combustion-support lines (13, 15) connected to the multiple pipe (125) comprises metering valves (13D, 15D) and other valve members (13V, 15V) controlled by the plant control means (100), these latter also being connected to pressure and temperature sensors (119, 118), to valve members (114, 115) and to a flowmeter (111K) positioned in or connected to the refuse feed line (2).

25. A plant as claimed in claim 1, **characterised by** comprising a gas cooling member (31) and control valves (38, 139) for separating the gas obtained by the refuse pyrolysis reaction within the reactor, said member being connected to a plant portion (33) arranged to recirculate said fluids through the plant, to said portion there being connected a line (35) comprising two branches (35A, 35B), a first branch (35A) directed to the reactor (1) and a second branch (35B) directed to a separation line (40) for the reaction gas produced.

26. A plant as claimed in claim 25, **characterised in that** the separation line (40) comprises catalytic converters (240), a filtration unit (241) to recover any powder present in the transiting fluid, a quenching unit (244) and a concentrator (247) to enable the CO_2 and H_2 present in said fluid to be separated and possibly recovered.

27. A method for treating refuse by pyrolysis in a plant in accordance with one or more of the preceding claims, **characterised in that** the refuse is pre-gasified and micro-disintegrated before being fed to a reactor (1) in which the pyrolysis takes place, the liquid part of said refuse being transformed into the gaseous phase and the micro-disintegrated solid part being fed with high temperature, high pressure steam to liquefy and then evaporate or sublime it before the refuse enters the reactor (1).

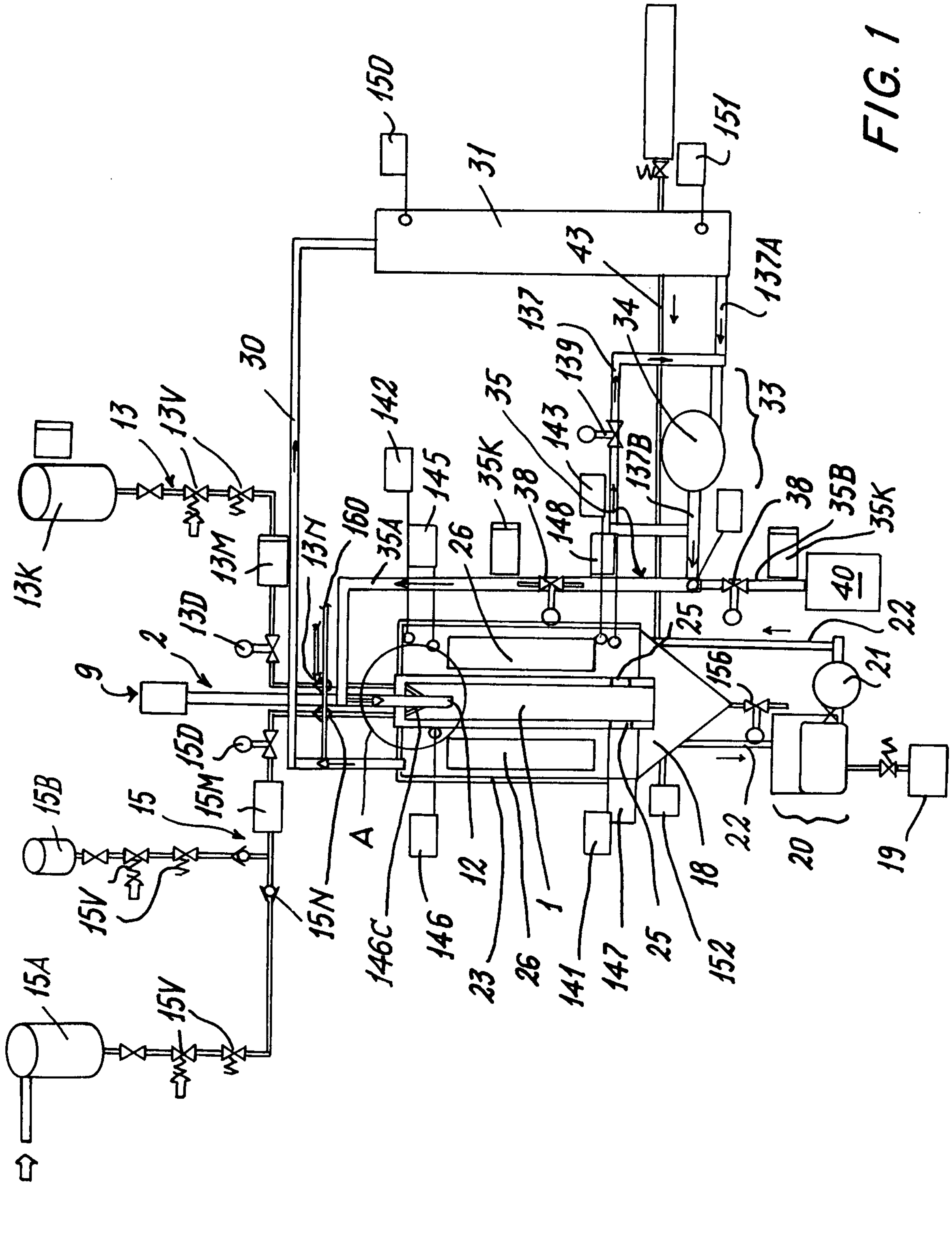
15A
15V
15B
15
15M
15D
15N
9
2
13D
13M
13K
13
13V
30
31
15D
151
43
137
137A
34
139
33
35
143
137B
142
145
35K
38
148
160
13N
35A
26
38
35B
35K
40
22
21
25
156
22
20
19
18
152
25
147
141
26
23
1
12
146
146C
A

FIG. 1

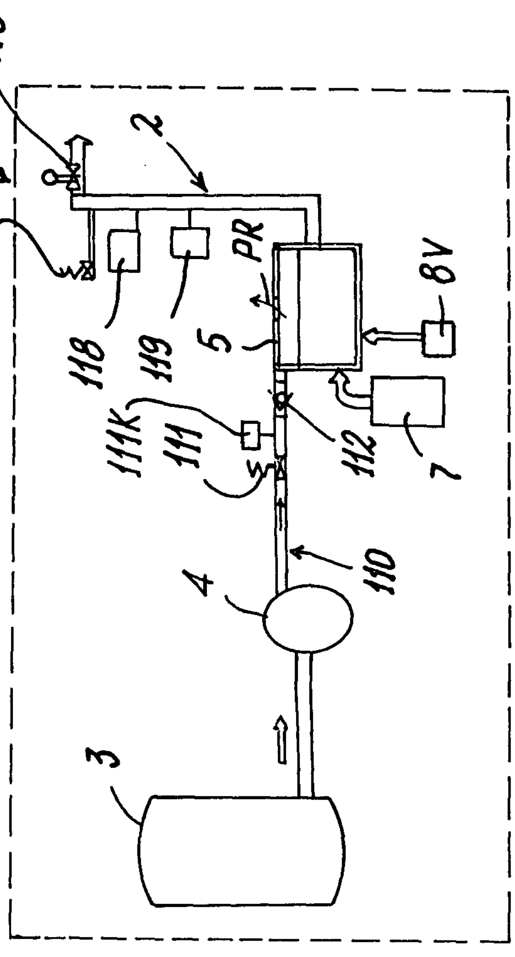

FIG. 2

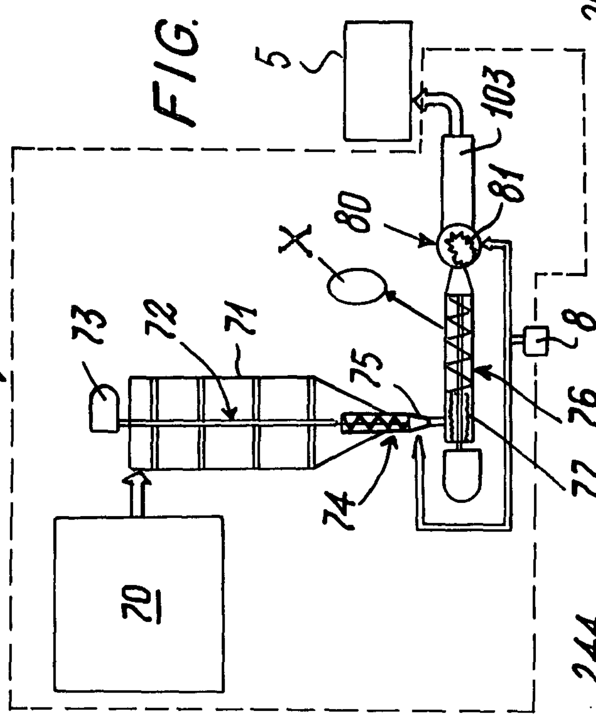

FIG. 3

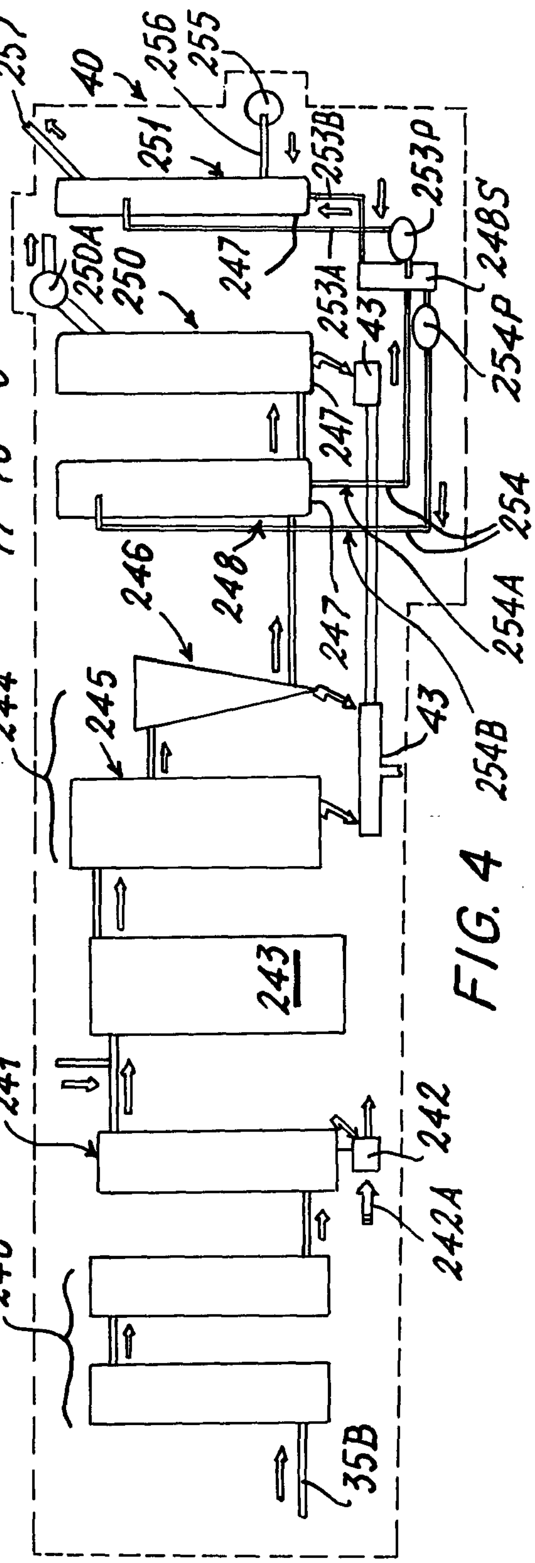

FIG. 4

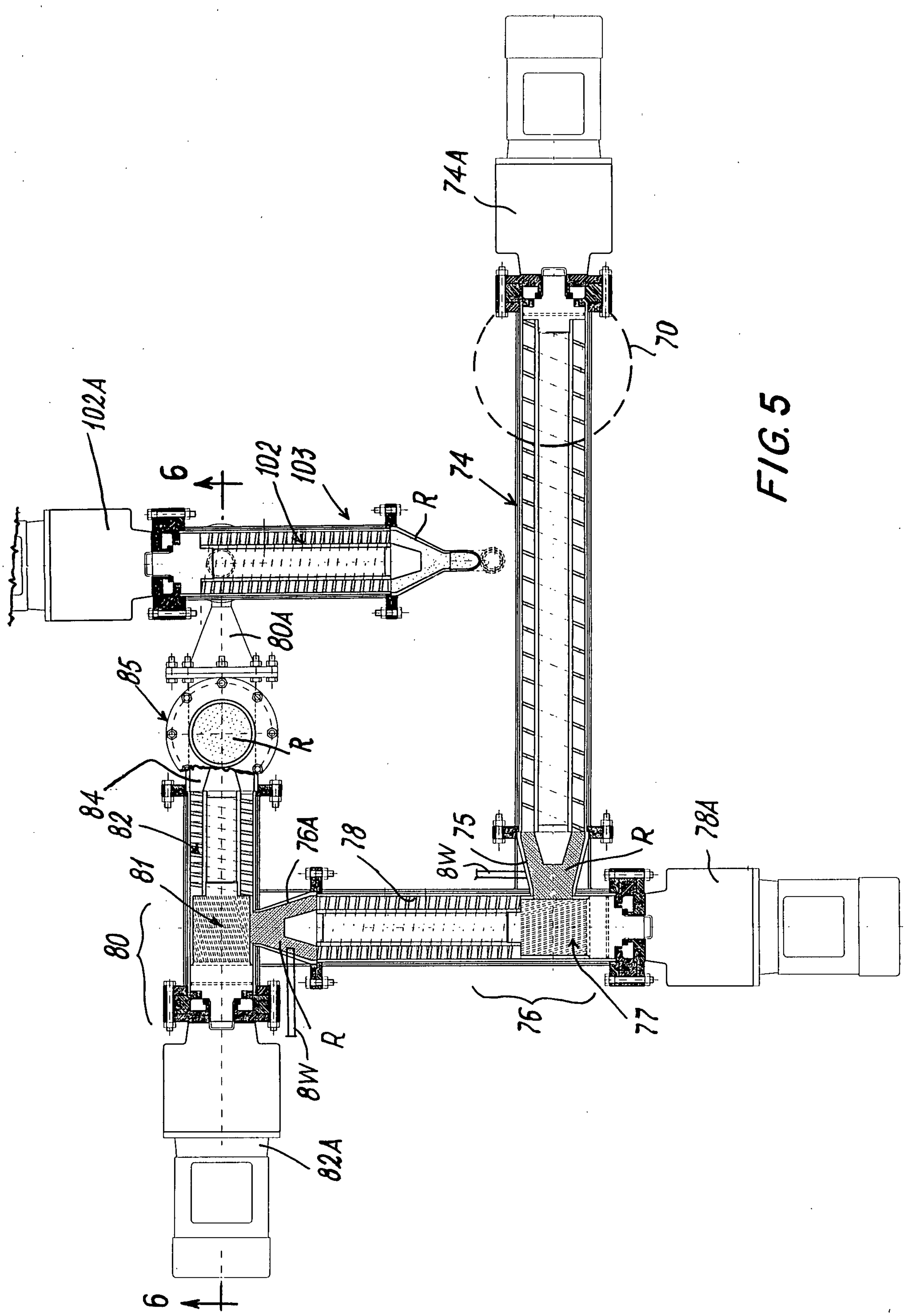
74A
70
74
102A
6
102
103
R
80A
85
R
84
82
76A
78
8W
75
R
78A
81
80
R
8W
76
77
82A
6

FIG. 5

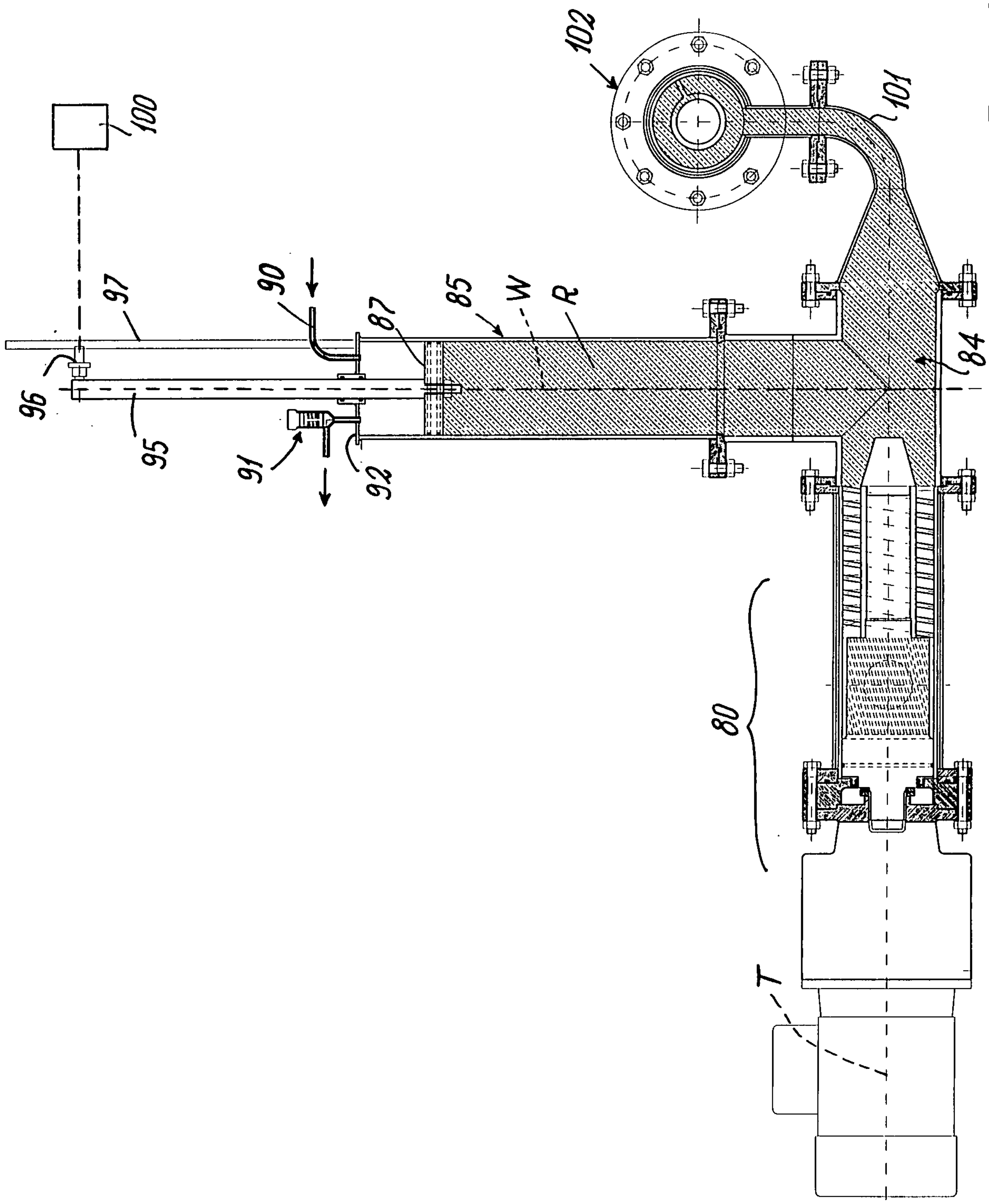

FIG. 6

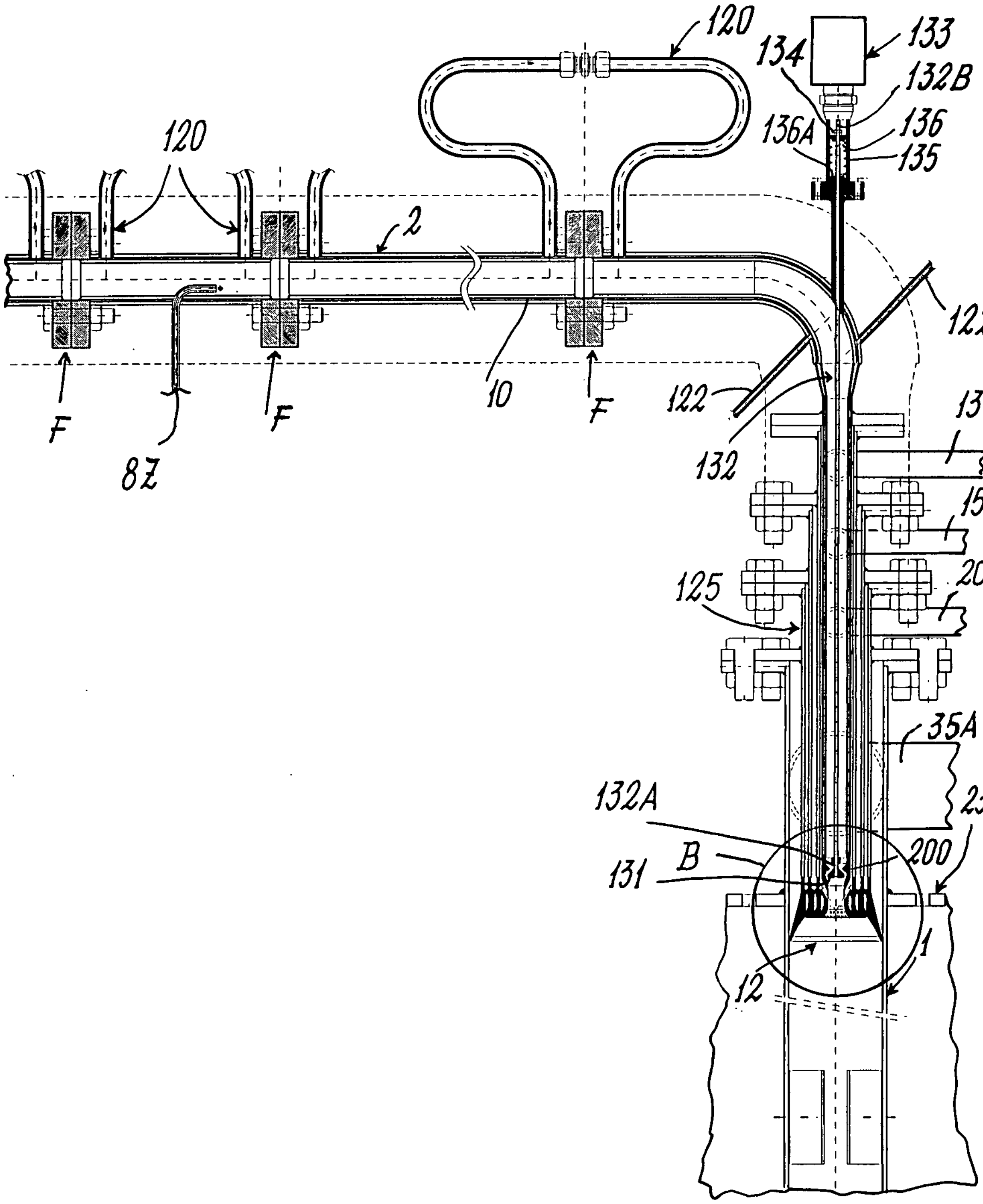
120
133
134
132B
136A
136
135
120
2
122
122
F
8Z
F
10
F
132
13
15
125
201
35A
132A
23
B
200
131
1
12

FIG. 7

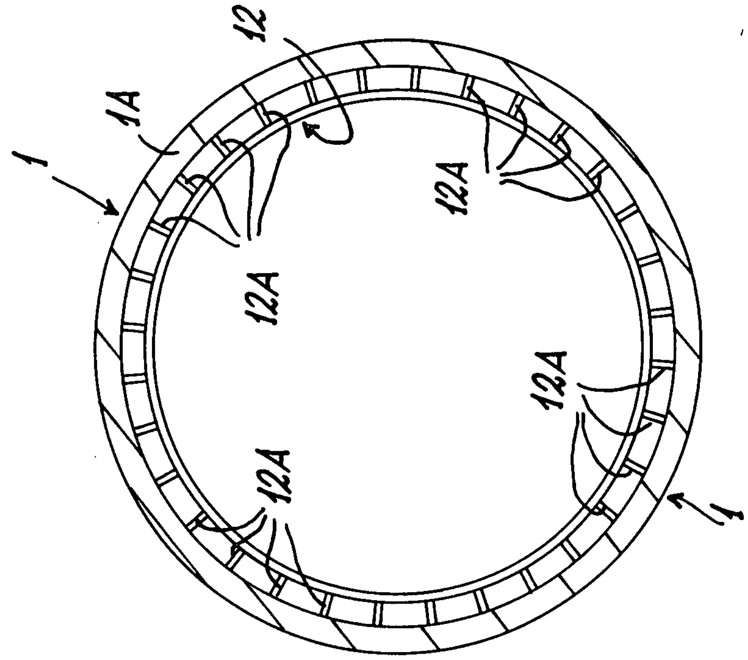
1
1A
12
12A
12A
12A
12A
12A
1

FIG. 9

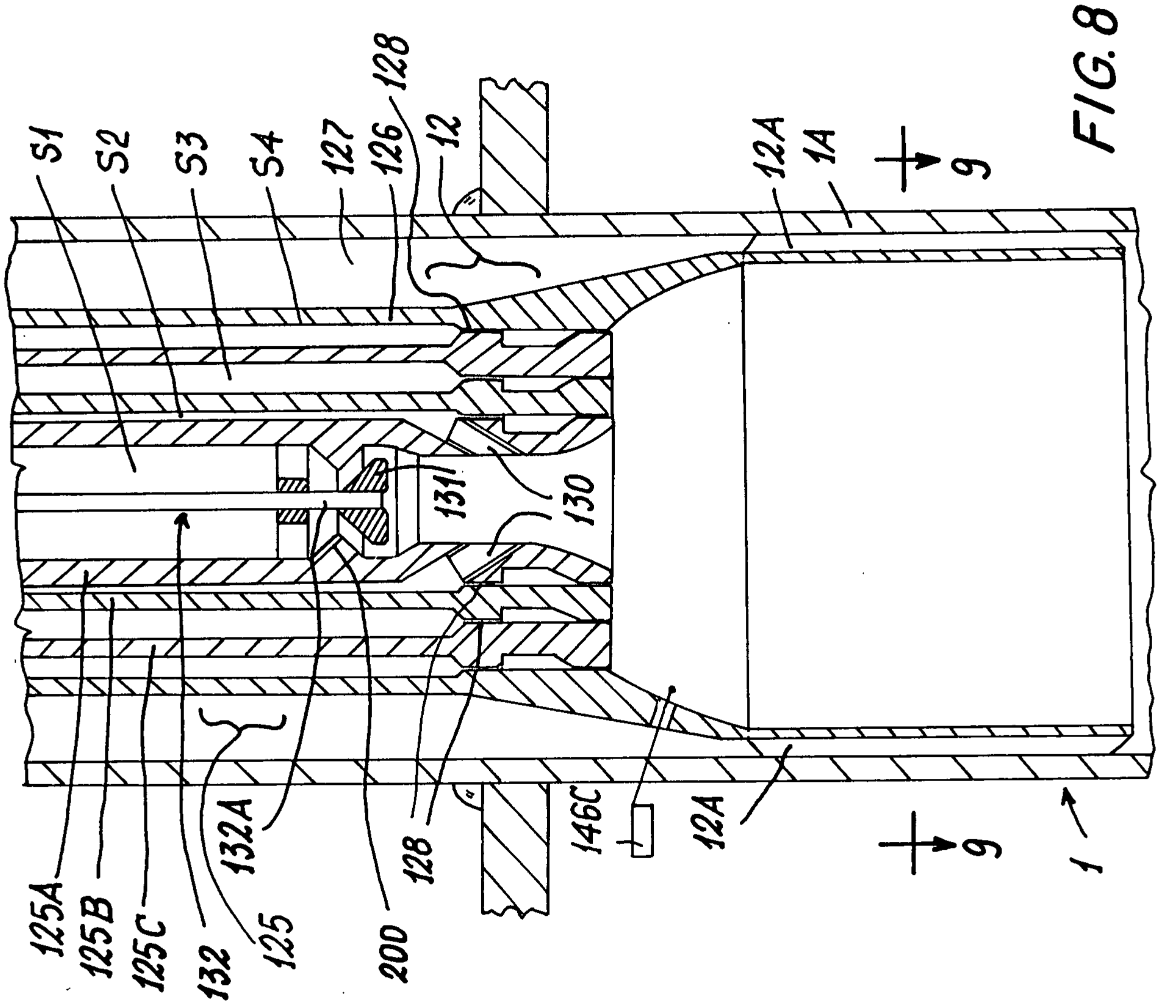
S1
S2
S3
S4
127
126
128
12
12A
1A
9
125A
125B
125C
132
132A
125
131
130
200
128
146C
12A
9
1

FIG. 8