



US 20100107493A1

(19) **United States**

(12) **Patent Application Publication**
Weaver

(10) **Pub. No.: US 2010/0107493 A1**

(43) **Pub. Date: May 6, 2010**

(54) **BULK FUELED GASIFIERS**

Related U.S. Application Data

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(60) Provisional application No. 60/846,790, filed on Sep. 22, 2006, provisional application No. 60/850,944, filed on Oct. 11, 2006, provisional application No. 60/875,483, filed on Dec. 18, 2006.

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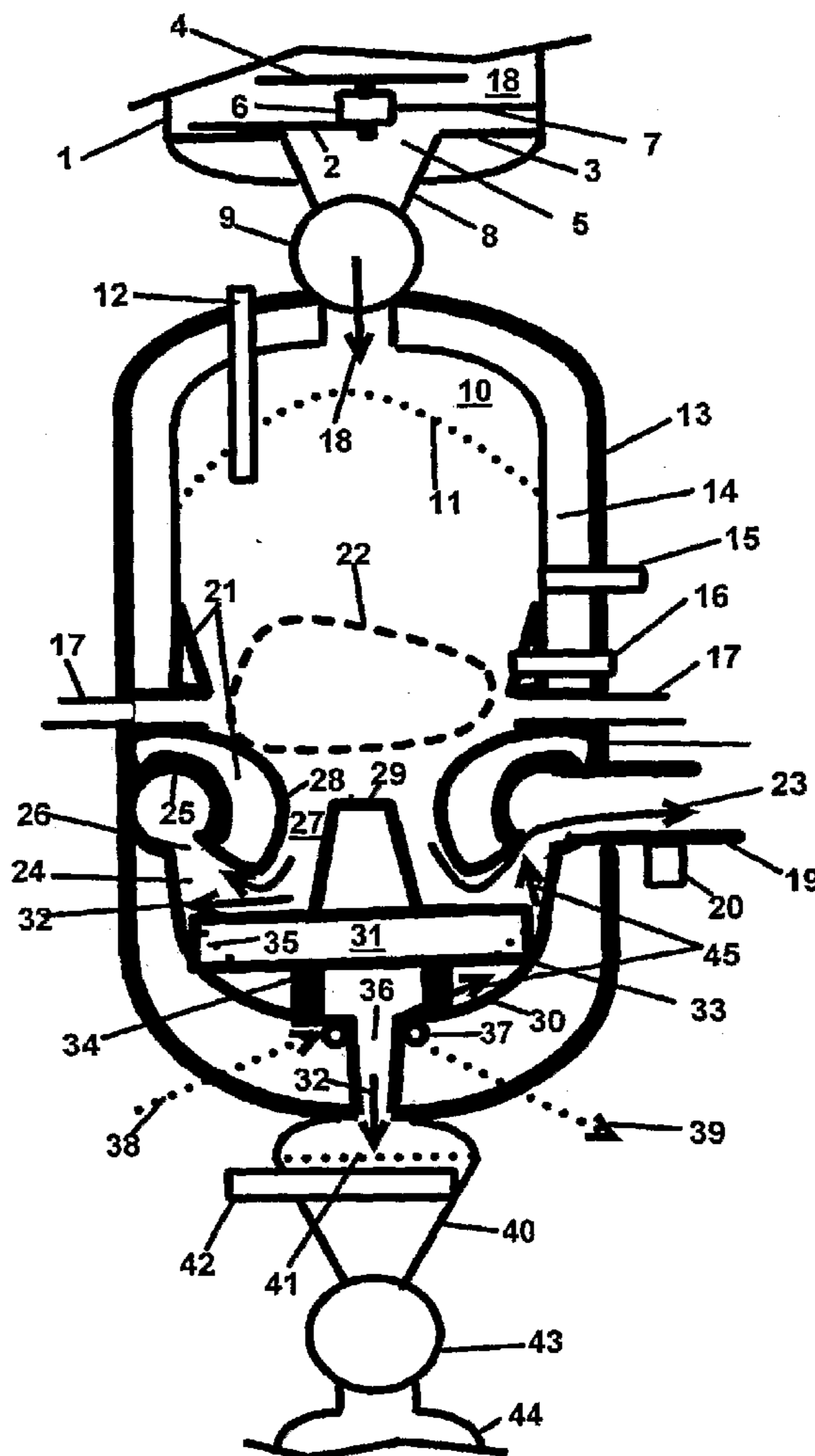
Publication Classification

(51) **Int. Cl.**
C10J 3/30 (2006.01)
(52) **U.S. Cl.** **48/86 R**

(21) Appl. No.: **12/442,215**
(22) PCT Filed: **Sep. 22, 2007**
(86) PCT No.: **PCT/US07/20555**

(57) **ABSTRACT**
A gasifier includes a gasifier shell, means for introducing fuel into the shell, and means for introducing oxygenate into the shell. The gasifier also includes means for discharging gas from the shell, which can be located below the means for introducing oxygenate. The gasifier can also include means for re-circulating gas prior to gas being discharged from the shell.

§ 371 (c)(1),
(2), (4) Date: **Jan. 14, 2010**



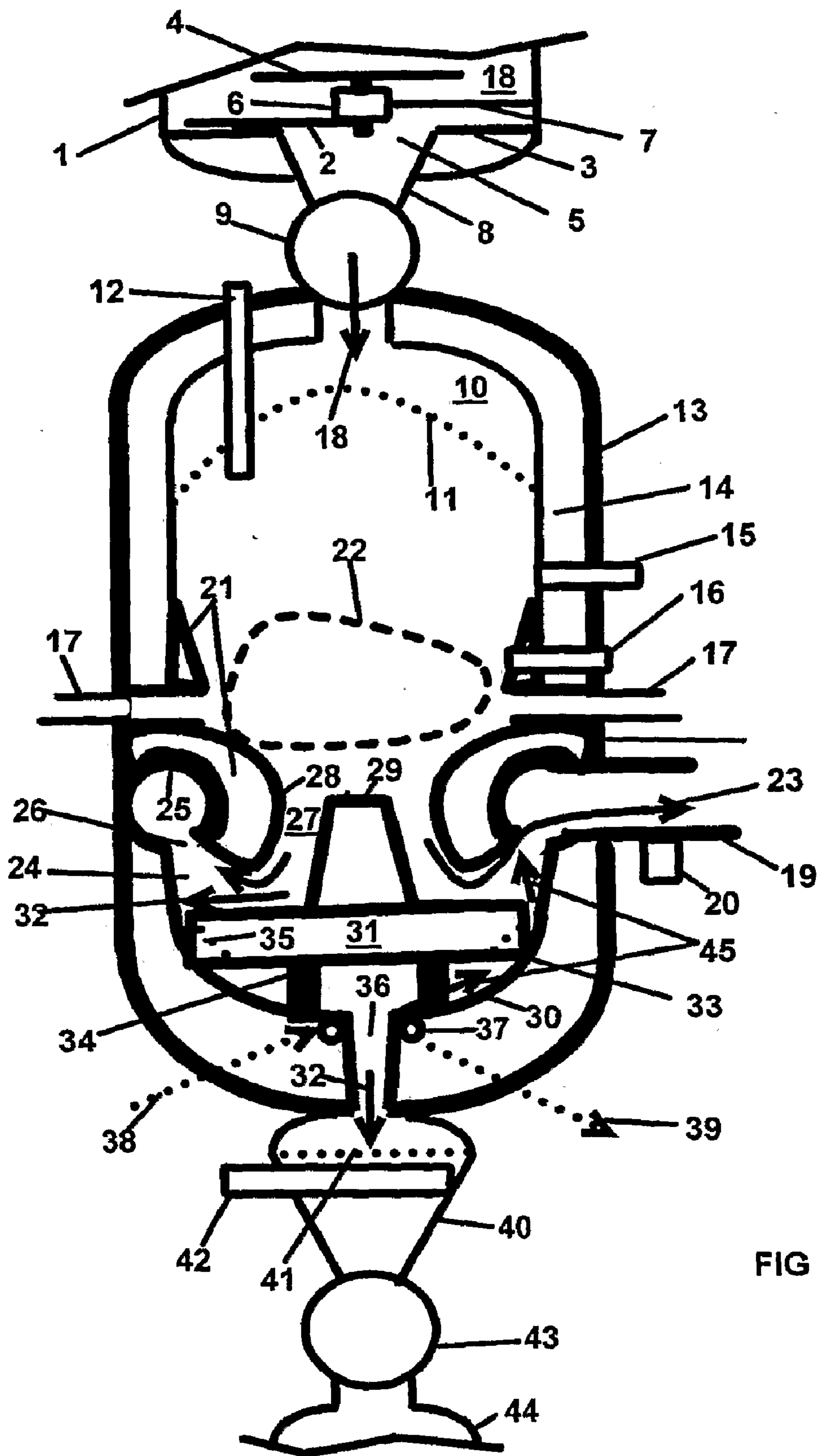
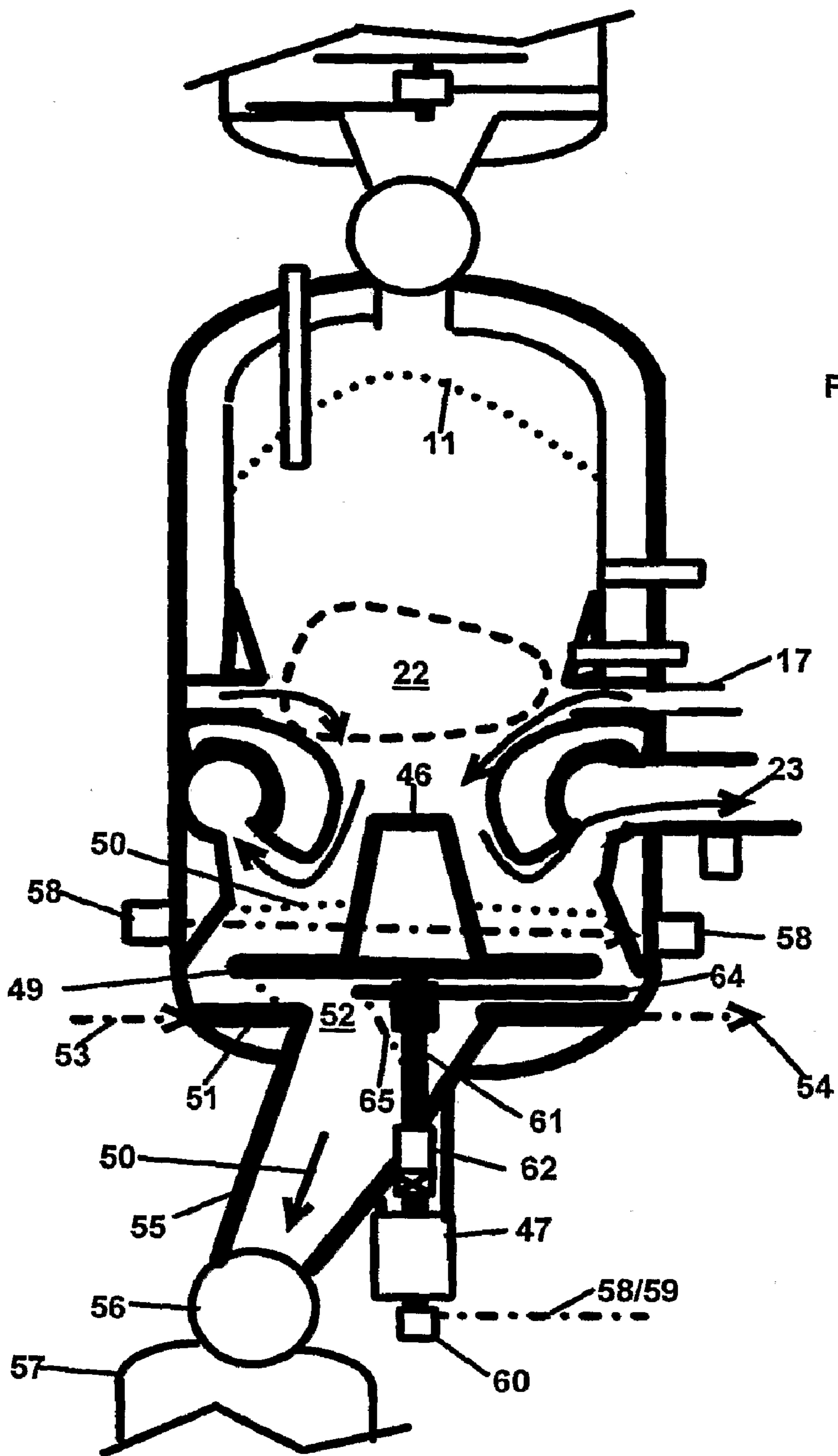
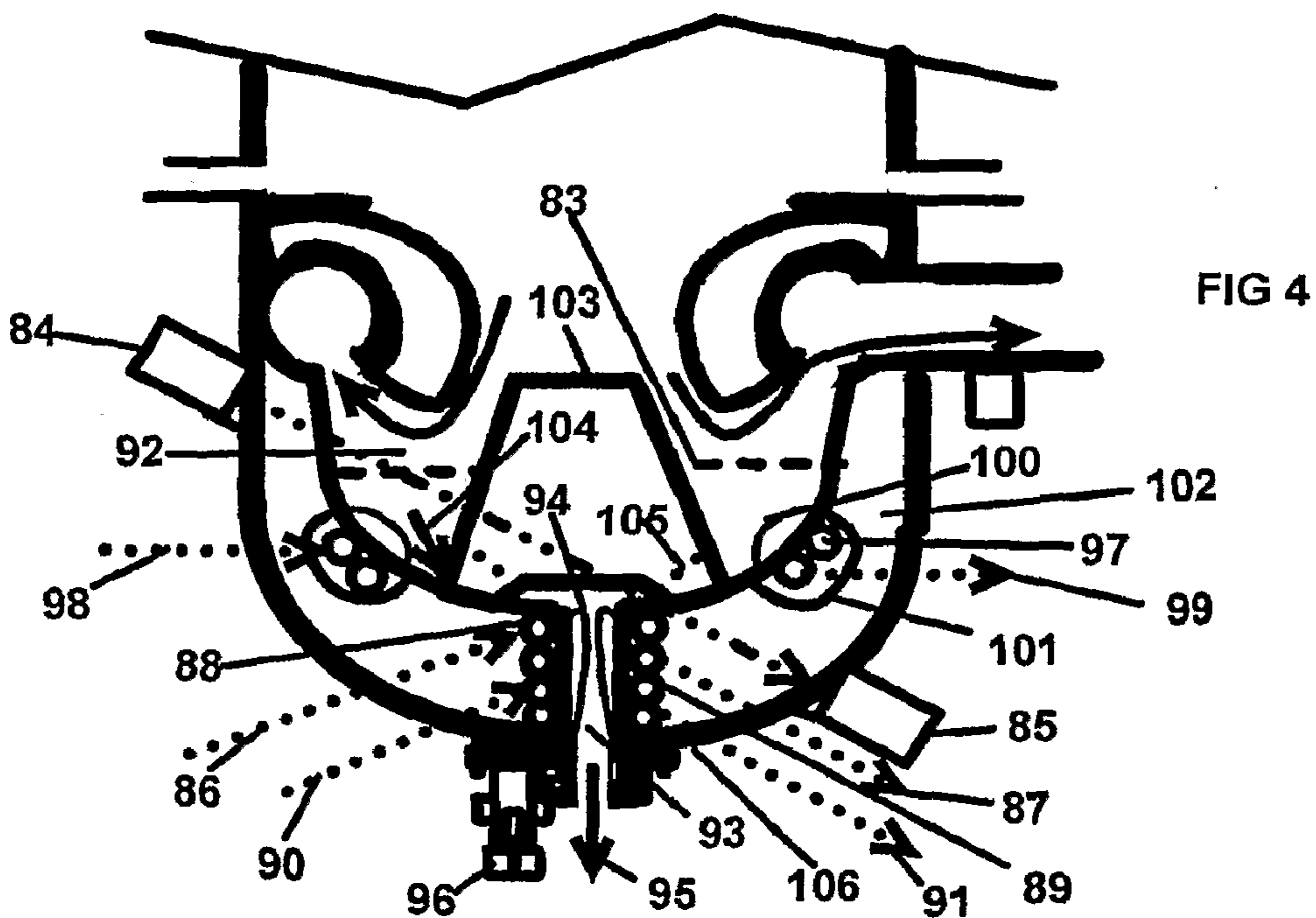
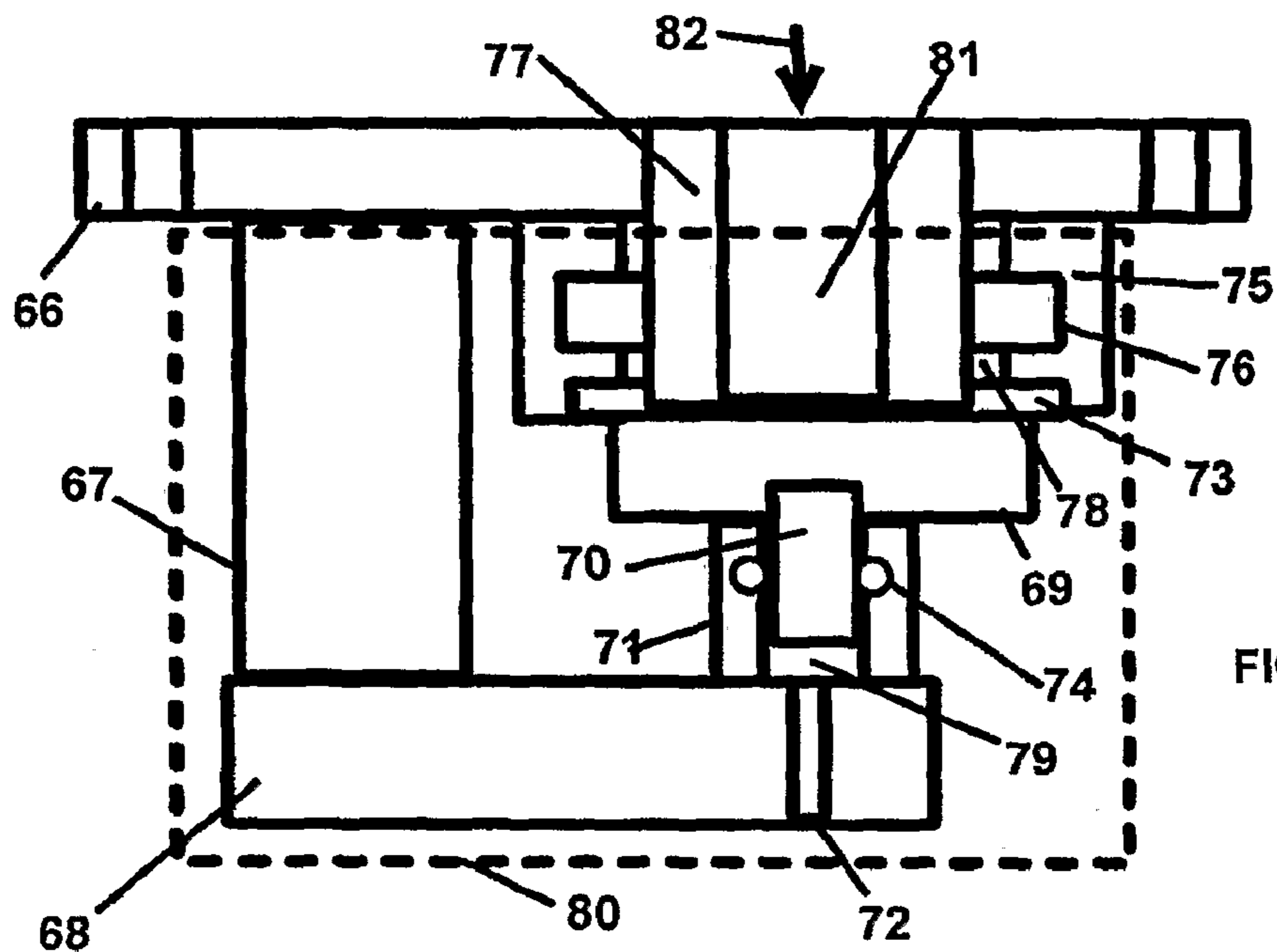


FIG 1





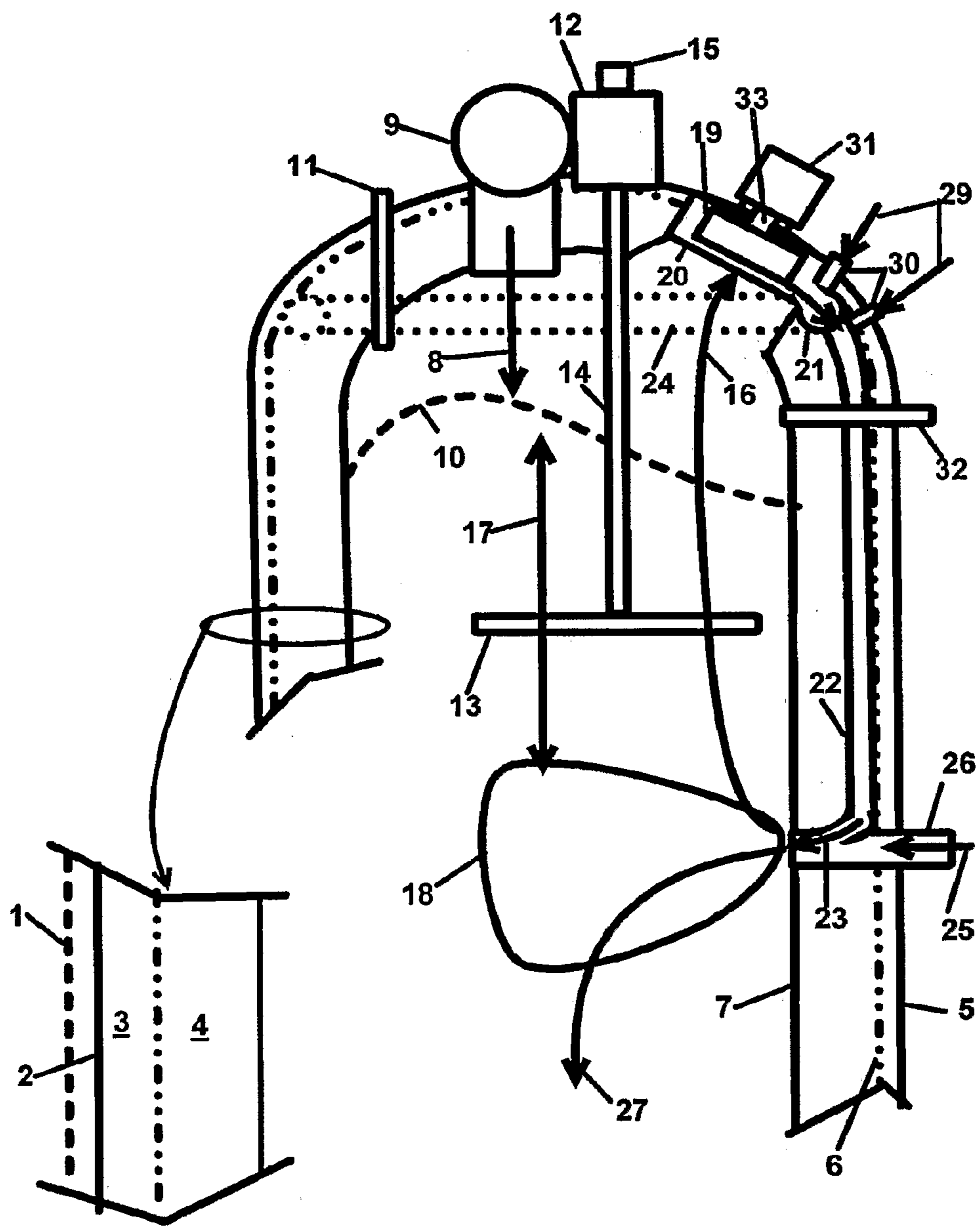


FIG. 6

FIG. 5

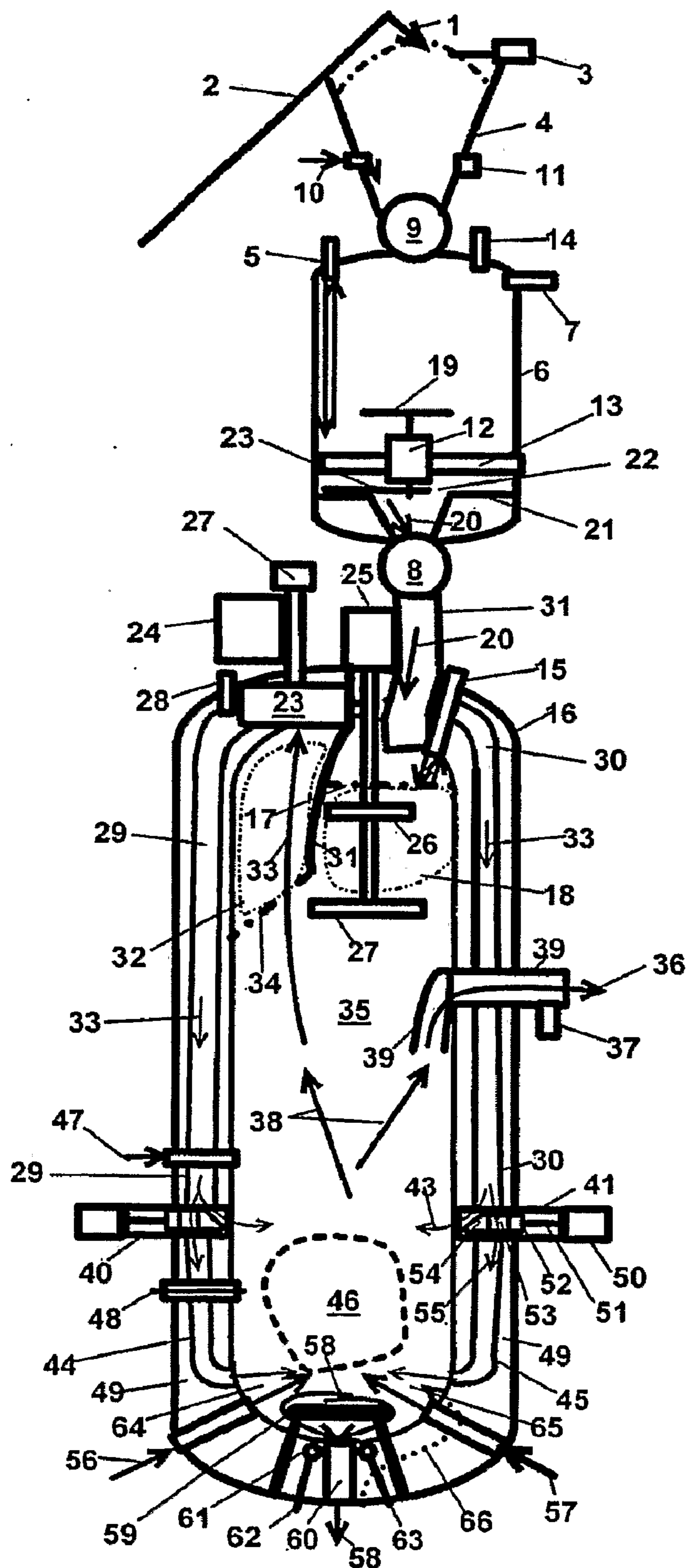


FIG 7

BULK FUELED GASIFIERS

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/846,790, filed Sep. 22, 2008, U.S. Provisional Application No. 60/850,944, filed Oct. 11, 2008, and U.S. Provisional Application No. 60/875,483, filed Dec. 18, 2008.

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to gasifiers. Two types of gasifiers are bulk fuel fed and entrained flow fed. Entrained flow fed gasifiers require more fuel processing such as pulverizers and slurring of coal, for example. Entrained flow also requires other extra equipment such as blowers and bag house. This extra fuel preparation increases the cost and complexity of the gasifier and also lowers reliability. Entrained flow gasifiers also tend to be very large and cumbersome, with present reliability so poor that two gasifiers are frequently supplied to do the job of one.

[0003] Bulk fuel fed gasifiers are generally simpler than entrained flow gasifiers, but they typically employ counter-current designs that tend to create undesirable tars. Tars that are very undesirable to further process gas either into syn-crude or for power plants because cleaning up the tars requires extra processes and coats the inside of gas piping, all of which increases gasification costs and decreases reliability.

[0004] Down draft gasifiers typically employ a co-current process in which tars are burned off and converted into a gas before exiting the process. However, down draft gasifiers generally have been limited to low fuel moisture levels because there was no method to dry the fuel within the gasifier. Updraft gasifiers can gasify much wetter fuels than downdraft units, because the hot gas exits through the fresh fuel mass. But the upper gas exit temperatures are limited in updraft gasifiers by the blast flow rate and how much heat energy can be pulled upwards. Similarly, downdraft gasifiers maintain a large fresh fuel mass above the fire or incandescent zone that unlike updraft processes has no hot gas continually flowing through it to dry it, and like updraft needs to maintain as hot an average a fuel mass as possible to maximize the output of the gasifier.

SUMMARY OF THE INVENTION

[0005] The above-mentioned problems are overcome by the present invention, one embodiment of which includes a gasifier including a gasifier shell, means for introducing fuel into the shell, and means for introducing oxygenate into the shell. The gasifier also includes means for discharging gas from the shell, which can be located below the means for introducing oxygenate. The gasifier can also include means for re-circulating gas prior to gas being discharged from the shell.

[0006] The present invention and its advantages over the prior art will be more readily understood upon reading the following detailed description and the appended claims with reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0007] The subject matter that is regarded as the invention is particularly pointed out and distinctly claimed in the concluding part of the specification. The invention, however, may

be best understood by reference to the following description taken in conjunction with the accompanying drawing figures in which:

[0008] FIG. 1 is a side of one embodiment of a gasifier.

[0009] FIG. 2 is a side of an alternative embodiment of a gasifier.

[0010] FIG. 3 is a side elevation view of a non-sticking valve useful in the gasifier of FIG. 4.

[0011] FIG. 4 is a partial side of an alternative gasifier.

[0012] FIG. 5 is a partial side of another embodiment of a gasifier.

[0013] FIG. 6 is a cutaway view of a portion of the wall of the gasifier of FIG. 5.

[0014] FIG. 7 is a side of yet another embodiment of a gasifier.

DETAILED DESCRIPTION OF THE INVENTION

[0015] FIG. 1 shows one embodiment of a slagging gasifier as if it is being used in a pressurized operation, say up to thirty bar pressures. Valve details and controls for de-pressurizing and re-pressurizing lock hoppers and controls are well known and are not shown. The upper and body sections are described first and are the same for each ash discharge method.

[0016] Lock hopper 1 is filled using a conveyor (not shown) that has a much faster capacity than the maximum usage of the gasifier. Undercutting rotating inward helical front edge of self-aligning plate 2 performs the unloading function by pulling material from the outer perimeter of base 3 and under rotating cap 4. The loose spline drive connection of unloader plate 2 to drive motor 6 allows plate 2 to conform perfectly to base 3 when rotating, reducing friction and eliminating binding forces. Cap 4 prevents free fall of fuel or material 18 into unloader concentric opening 5. In conjunction with inward rotating helix plate 2, materials caught in between the bottom of cap 4 and top of base 3 are broken apart by such grinding action. This is useful for unloaders unloading ash that may contain large clinkers. Drive motor 6 is supported by inside braces 7 attached to the inside of the lock hopper 1. Unloaded material 18 slides down through cone funnel 8 through lower lock hopper valve 9 (typically a sliding disk-type valve such as a higher temperature Everlasting™ valve) into gasifier upper zone 10 to form material level 11, which surges up and down in level slightly as there is no feed as the hopper 1 is refilled by its high capacity conveyor (not shown). Level 11 is measured by vertical sensor 12, and the level data is issued to control the speed of the drive motor 6, including using higher speeds at first after refilling the lock hopper 1 to recover level 11.

[0017] The gasifier includes a water cooled gasifier shell 13, and the midsection of the shell 13 has a thick, high temperature refractory 14 penetrated by at least two levels of 3000 F rated gas cooled thermocouple temperature sensors 15 and 16, steam and oxygenate (e.g., O₂ or air) feed tubes 17, and a final exhaust water cooled and ceramic lined gas exit pipe 19 extending through the shell 13. A combined sensor 20 mounted under the gas exit pipe 19 includes duplex thermocouples like 15 or 16 plus a CO₂ sampling sensor. Refractory 14 is further reinforced with a high temperature rated refractory coating 21 throughout an ash incandescent zone 22 and ash or slag removal zone discussed below. Gas 23 produced in the gasifier exits by cone shaped spaces 24 through underside openings 26 of a water-cooled and lined torus shaped pipe 25 mounted inside the gasifier shell 13 and passes out through the exit pipe 19, which is in fluid communication with the

torus shaped pipe 25. Intense gasification within incandescent zone 22 feeds gas down through a cone volume 27 formed by an extra high temperature refractory, torus-shaped nose 28 mounted on the torus shaped pipe 25 and a cone solid 29 centered with respect to the torus. The gas 23 passing through this space and up through cone shaped spaces 24 completes the reduction reactions that burn off tars to make a tar free gas for subsequent filtering prior to other operations. The combined reaction time for a given gas flow when combining the incandescent zone 22 with the cone volume 27, the torus-shaped nose 28 and the torus-shaped pipe 25, recognizing that raising the position of the steam and oxidizer feed pipes 17 or adding additional feed pipes 17 further increases the volume of the incandescent zone 22, will be determined by computer simulation and/or experiment but is expected to be about 1 second in duration. It is also possible to make oxidizer and steam feed pipes 17 separate pipes to improve on combustion and then gasification taking place within the perimeter space of the zone 22, which is also a design detail that would be determined by computer simulation and/or experiment.

[0018] A lower slag rejection space 30 is defined by the extra high temperature refractory 14 and refractory coatings 21. The high temperatures achieved in the incandescent zone 22, which is over the slagging temperature for coal or from about 2350-2700 F, will create a continuously running flow of slag 32 around the torus-shaped nose 28 and the cone solid 29. The cone solid 29 is located across the top of an inclined, refractory disk 31 (inclined at about three degrees) that is supported on its perimeter at 33 and by posts 34. Molten slag flow 32 passes through notches 35 molded in refractory disk 31 around support posts 34 to enter a tap hole 36 which at the top has an optional inductive copper coil 37 to melt slag at the tap hole 36 as needed and is fed power and water coolant at 38 and which exits as water and power connection 39. Coolant flow is constant to insure copper coil 37 doesn't melt. But inductive power would not be used unless tap hole 36 is plugged which can be determined by the failure of the slag lock hopper 44 to fill. Plugging of the tap hole 36 is also unlikely if the incandescent temperature of zone 22 is maintained sufficient as measured by the temperature sensor 16. Leaving tap hole 36, the slag 32 enters a quenching vessel 40 with maintained water level 41 and having an optional slag grinder 42, which should not be needed if a fast unloader is added to the slag lock hopper. Details of a water system to fill the vessel 40 are not shown but are well known in the art. Slag 32 flows through a valve 43 (such as an Everlasting™ valve) into the slag lock hopper 44, which will typically have a slag rejection valve (not shown) that is similar to the valve 43. Steam 45 from quenching the slag 32 rises to combine with exit gas 23. Water flow control to replenish the water level 41 of the quench vessel 40 is not shown and is well known in the art.

[0019] To start the gasifier, after preheating refractory, the cone volume 27 is filled with chunk sized stove wood up to the feed tubes 17, and the shell 13 is then filled with coal to level 11. An igniter burner (not shown) is inserted into the feed tube 17 to ignite the wood coal area, then oxygenate blast flow is ramped up. Such igniters can be permanently built into the feed tube 17. By virtue of the exit pipe 19 being located below the feed tubes, and thus below the incandescent zone 22, the gasifier provides a co-current process that burns off tars

before the exit gas 23 is discharged. In other words, the fuel 18 and the gas 23 flow in essentially the same direction through the interior of the shell 13.

[0020] Referring to FIG. 2, an alternative approach for dry ash removal, that is still capable of pressurized operation, is described. The feed and body of the gasifier is the same as described above, so just the ash removal section will be described here. This is a lower temperature version of the gasifier whereby the temperatures maintained in the incandescent zone 22 are maintained below slagging conditions, or generally under 2300 F. The ash unloader has a raised solid high strength refractory cone 46 around which the gas 23 passes to insure tars are burned off. The design rules of thumb for sufficient incandescent zone plus following volumes and gas retention time for fuel to gasify and burn off tars discussed above in connection with FIG. 1 also apply to this lower temperature dry ash process. A drive gearhead 47 rotates cone 46 and its supporting disk 49 which will support any ash or clinkered mass that falls within this space and which are broken up by all rotating members. Because of wear and because it is a hot area, cone 49 is coated with high temperature silicon carbide or has other wear and heat resistant inserts on its top surface so as to withstand this severe duty. Also, rotating elements are water cooled which helps prolong their life. Construction of such rotating ash unloading conical structures has the advantage that it is solid and water cooled which should prolong its life even more. Also, a thicker helical front face can be specified which enables the ash unloading assembly to rotate even slower. Ash and/or clinkers 50 accumulate and rest on independently water-cooled support base 51, cooled by water inflows and outflows 53 and 54, respectively. A center hole 52 is provided for ash discharge through right angle cone transition piece 55 through a high temperature valve 56 to a lock hopper vessel 57 (partially shown). An ash proximity sensor 58, such a nuclear gage or air cooled point-type reflective gages, could be used with sample-data control algorithms used to maintain a constant speed to the unloader drive, maintains a nearly constant bed of ash level within the this space. In the case of the nuclear sensors, they are off-side so as to only measure ash or slag materials, but not the center cone 46. While the lock hopper 57 empties, some ash may accumulate atop closed valve 56, but also the rotation of unloader helix 64, which rotates with the disk 49 and the cone 46 respectively, may be momentarily stopped until hopper unloading is complete. The lock hopper 57 may also have an unloader (not shown) to quickly discharge ash to atmosphere. Coolant for drive shaft 61 and support bearing/seal 62 is fed coolant water in at 58 and out at 59 through rotary valve 60. The same coolant travels up and down shaft 61 and is fed in and out of floating unloading helix 64 through high temperature metallic covered hoses 65. Water ash quenching in the lock hopper 57 could be used if needed, which adds steam flow to the outlet gas 23.

[0021] To start the gasifier, after preheating refractory, ash is filled to the sensor level 58, and from there to the feed tube 17 is filled with chunk sized stove wood and then filled with wood or coal to level 11 with an igniter burner (not shown) inserted in the feed tube 17 to ignite the wood coal area and then ramp up oxygenate blast flow. Such igniters can be built into tube 17; ash rejection is held under manual control until the chunk wood is consumed.

[0022] FIG. 3 depicts a high temperature disk valve with inductive heating method to unstick the valve in the event it freezes open or shut based on the molten slag that will become

deposited on the valve disk surfaces as it operates. The use of this valve is shown in FIG. 4 as an emergency molten slag flow shutoff valve when discharging high-pressure slag. Generally the valve is open allowing slag to continuously flow out. The valve is constructed around flange 66 with actuator 67 that rotates arm 68 which rotates ceramic disk 69 to open or close discharge opening 81 formed by ceramic cylinder 77 attached to flange 66. Piston 70 imbedded in disk 69 is also held within cylinder 71 attached to arm 68. Oil pressure through opening 72 into top of piston space 79 forces disk 69 against tungsten disk 73 to perform the leak-proof shutoff function. "O" ring 74 prevents oil from leaking by piston 70 and cylinder 71 combination. When opening and shutting, disk 73 is heated to insure solidified slag either on disk 69 or disk 73 becomes molten allowing a flush non-leaking seal. To provide high temperature heating, there is a non-conducting cylinder 75 which has induction coil 76 surrounding it which is supported by an inside groove in outer non-conducting cylinder 75. Conducting tungsten disk 73 is also supported by an inside groove in 75. Air gap 78 is small to increase the heating effectiveness of coil 76 to disk 73. When high frequency current is applied to coil 76, the tungsten disk 73 can get hot enough to melt the slag to unstick the two surfaces of disk 73 and disk 69, or also melt deposited solidified slag to allow the disk 69 to slide shut and to re-seal as noted previously. A heat shield 80 depicted as dashed line is attached to one side of swinging arm 68 such that when the valve is open, i.e. disk 69 swung away from opening 81, hot material 82 pouring from opening 81 will not damage actuating parts.

[0023] FIG. 4 depicts just the lower slag area of FIG. 1 but shows an alternative direct molten slag discharge method and control thereof without using quenching or lock hoppers. In this instance, the gas discharge area 92 has a constant slag level 83 as measured by a nuclear gage comprised of emitter 84 and receiver 85. They are located to measure slag depth off-side, i.e. do not detect item 104. To maintain level 83, computer control algorithms are designed to manipulate the super chilled water inflow 86 and outflow 87 for upper multiple coil 88 and similarly for lower multiple coil 89 a lower chilled water temperature inflow 90 and with outflow 91 which creates a tapered opening 93 formed as slag solidifies onto the coils, shown as slag coating 94, such that the duplex coil region (or more if required) acts as a high pressure flow control for the pressure reduction of slag from say thirty bars pressure at level 83 to atmospheric pressure where the slag 95 leaves the emergency shutoff valve 96 described in FIG. 3 above (in this instance valve 96 shown as maintained open). Further, coolant in feed and out feed copper pipes to copper coils 88 and 89 respectively can also have inductive currents to melt away some of slag build-up 94 should opening 93 become frozen shut, which would cause level 83 to rise to an unacceptable level. From time to time it may be necessary to provide inductive heating to slag mass to maintain molten conditions, thus inductive coil 97 provides the needed energy which has constant coolant in-flow 98 and outflow 99, which also serve as inductive current carriers. Coolant flow maintains coil 97 protective slag coating 100 and the coil also has electrical back insulation 101 imbedded in refractory 102. To provide a converging area for co-current gasification to take place, cone shaped riser 103 made from high temperature refractory is attached to the bottom of refractory 102. Slag 104 flows under notches 105 cast in the base of cone 103 to enter the controlled tap hole opening 93 to leave as molten slag flow 95. A much longer length to slag opening 93 can be

created by adding more coil sections like 88 and 89 as indicated previously, and can be engineered in the base of refractory area 102 by extension of lower gasifier housing 106 such as using a pipe extension before attaching safety shutoff valve 96. A longer length to opening 93 may be needed such that the viscosity change in the slag to dissipate the pressure energy will enable a lower velocity of slag flow 95 from the exit point of safety shutoff valve 96.

[0024] To start the gasifier, after preheating refractory, molten slag is added to reach level 83 and maintained molten with inductive energy to coil 97 while filling the remainder of the gasifier with coal to level 11 (not shown but the same level as in FIG. 1) and with an igniter burner (not shown) inserted in feed tube 17 to ignite the coal and then ramp up oxygenate blast flow. Such igniters can be permanently built into tube 17.

[0025] FIG. 5 shows another embodiment of a gasifier that is similar to the gasifier of FIG. 1 but includes means for hot gas re-circulation. Ash rejection and gas out details can be the same as described in connection with the above embodiments and are thus not described here. This gasifier includes an outer steel shell 5 having an insulation limit 6 and a refractory thickness limit 7. Referring to FIG. 6, an enlarged cross section of the outer steel shell 5 shows the wall thickness details. Item 1 is an outer dimpled wall for a steel pressure shell 2, which provides for a water cooling method generally comprising a forced water circulating method feeding a steam drum above, details not shown but well known in the art. Item 3 is the insulation next to shell 2, and item 4 is the thick refractory, up to 14 inches thick.

[0026] Returning to FIG. 5, fresh fuel 8 is fed through a lock hopper valve 9 to a controlled level 10. The inclined fuel level 10 is measured with a high temperature level sensor 11, which is preferably a gas purged infrared or radar sensor but other sensors can also be used if able to withstand the temperature of the re-circulating gas 16.

[0027] A motorized gearhead 12 drives an agitator 13 located in the fresh fuel zone 17 via a shaft 14, which is water cooled through a rotary valve 15. The agitator 13 also levelizes the fuel level 10. Note that re-circulating gas flow 16 causes gasification of the upper fuel zone 17 to start, including caking. Thus, the agitator 13 operates to break up caking and insure relatively uniform gas flows 16 up through the fuel zone 17. Extending the length of the shaft 14 and providing multiple agitating bars to the agitator 13 can increase the drying potential for downdraft units.

[0028] Hot, re-circulation gases 16 are pulled up from the fire or incandescent zone 18 by a rotating blower impeller 19 mounted within the inside gasifier case 20 at or near the top of the shell 5. In one embodiment, the blower impeller 19 is mounted just inside the gasifier shell 5 within a water-cooled blower case. For example, coolant could be fed through rotary joints (not shown) to cool the impeller vanes, and a separate center pipe (not shown) could periodically feed higher pressure steam to blast clean the surfaces of the vanes. Furthermore, blower pre-filters and tar conversion devices outside the gasifier shell 5 could be provided as well to lessen the particulate and tars loading on the blower impeller 19. The output of the blower impeller 19 is fed to a hollow, torus-shaped plenum 21 in the upper zone of the gasifier shell 5, which in turn feeds hot gas down through individual ceramic vertical tubes 22 located in the wall of shell 5 around the circumference of the shell 5. It should be noted that the pressure needed to re-circulate the gases 16 is relatively low,

meaning that the gasifier does not require much energy to re-circulate the gases 16. Also, the plenum 21 could be rectangular in cross section.

[0029] The blower impeller 19 forces the gases 16 into the plenum 21 and down through ceramic down-flow tubes 22 to combine as gas 23 in the feed or blast tube 26 which has oxidant blast 25. This creates the incandescent zone 18, which can be extended vertically depending on the staggered number of blast tubes 26 (only one is shown with its corresponding ceramic down-flow tube 22). By re-circulating the hot gases 16 up through the fuel zone 17, the fuel is dried. Accordingly, the overall downdraft process now has the advantages of updraft fuel drying plus the steam from the wet fuel is transferred to the incandescent zone 18 where it facilitates gasification reactions, reducing the amount of extra blast steam needed depending on the moisture content of the fuel. Also, since the whole fuel mass is at a higher average temperature, the output capability of the gasifiers will be improved. Furthermore, because the gases 16 are hot, tars and particulates are minimized. Accordingly, the re-circulating gases 16 are not necessarily cleaned prior to re-circulating as gas 23 into the fire zone 18 of the gasifier, although such cleaning could be performed if desired. Note that the plenum 21 has a toroidal shape extending around the upper gasifier inner shell, as depicted by dotted line 24. The final gas leaves as down-flow 27, when operating as a co-current or downdraft gasifier (27 flow would be upwards when operating as an updraft gasifier), which combine to pass through a cross section restricted lower area (not shown) to finish burning of tars and then exiting the gasifier. As mentioned above ash or slag removal can be accomplished in the manner described above. Note that the blower impeller 19 and the down-flow tubes 22 are located within the gasifier steel shell 5, which if pressurized more, the upper design horsepower for motor 31 increases and thickness of impeller 19 increases as gases 16 become more dense.

[0030] While the tar content of the re-circulated gas 16 will be small at these higher temperatures, there may be some particulate matter and tar that could plug the down-flow tubes 22. To insure the ceramic tubes 22 do not plug from any tars and particulate that may be blown by the impeller 19, air 29 is periodically injected through valves 30 causing a fire to happen within plenum 21 and the down tubes 22 (like a chimney fire, but the fire is blown downwards) to burn off this material whose ash combines to form a part of gas injection 23. The valves 30 are purged with nitrogen (not shown) so they will not be damaged when there is no air flow 29. Also, the speed of the blower impeller 19, as driven by variable speed motor 31, is determined by the maximum allowable temperature of the re-circulated gas 16 as measured by thermocouple 32, which must not exceed the temperature rating of the blower, which is generally about 2000 F. Item 33 is the seal and bearing area of the blower housing 20; the arrangement of this is well known in the art, including materials, cooling slingers, gas purging, and any other means to insure a long life for blower impeller 19 and inner case 20.

[0031] Referring to FIG. 7, yet another embodiment of a pressurized gasifier 16 is shown. In this embodiment, fuel 1 is periodically fed to a holding hopper 4 using a conveyor 2. A level probe 3 determines when the hopper 4 is full to shut off the conveyor 2. Another level probe 5 measures material level in a lock hopper 6. When level probe 5 determines the lock hopper 6 is near empty (as shown), a discharge dome valve 8 is closed and the hopper 6 is decompressed by opening valve

7, and then dome valve 9 opens to allow fuel 1 from the filled chute hopper 4 to rapidly fill lock hopper 6. Just enough material is added to chute hopper 4 each fill cycle to refill hopper 6. Hopper 4 can have air inlets 10 (one shown) to prevent any suction effects from the rapid flow of material out of hopper 4 from flowing through valve 9, and/or vibrators 11 (one shown) to assist the rapid discharge of hopper 4. Hopper 4 can also be lined with HDPE plastic sheet to facilitate flow. When the hopper 4 is emptied (and hopper 6 is refilled), valve 9 is closed, hopper 6 is re-pressurized with gas via valve 14. The gas could be air, CO₂, nitrogen, or any other suitable gas applicable to the gasifier design. Then, the valve 8 is reopened so unloader drive 12 can begin to rapidly unload hopper 6 of material 20 to replenish fuel zone 18 inside the gasifier 16, now at a lower level due to the refill time interval for hopper 6 to reestablish upper level 17 as measured by level probe, which can be a radar probe.

[0032] Unlike most lock hoppers, hopper 6 has an unloader so as to be able to handle a larger range of material, and it consists of electric motor gear head drive 12 supported by channel iron supports 13, the speed of drive 12 is controlled by the level probe 15. The lower the level 17 of upper feed zone 18 of gasifier 16, the faster the drive 12 is operated to refill zone 18 faster. Drive 12 has a double ended shaft to both drive a top circular disk 19 which orientates material 20 and prevents uncontrolled flow through opening 22. There is unloader plate 21 with opening 22, and a lower unloading floating flat plate 23 driven by a loose spline arrangement (not shown) on the lower shaft of drive 12, plate 23 resting and freely able to orient to plate 21 to eliminate binding forces. Plate 23 has a helical shaped leading edge cut so as to spiral material into the opening 22. The material 20 flows through a chute 31 into the fuel zone 18. As noted above, the level of material in zone 18 is allowed to drop while the lock hopper 6 is being refilled by hopper 4. This simplifies the feed arrangement and takes maximum advantage of the fresh fuel zone 18, the level surge of which will have no deleterious effects on gasifier operation since this is the fresh fuel zone 18 where essentially no gasification is taking place.

[0033] The gasifier 16 has a re-circulating blower 23 driven by a variable speed motor 24 and re-circulation tubes 29 and 30 formed in the wall of the gasifier shell and running lengthwise therein. There is constant speed stirrer 25 with blades 26 and 27, shaft seals not shown. Air injection valves 28 (one shown) enables the re-circulation tubes 29 and 30, respectively, to periodically be burned free of accumulating soot matter. There is a water cooled chute 31 that creates upper zone 18 in the upper gasifier area but also an empty zone 32, which is where re-circulating gas 33 enters blower 23, and empty zone 32 also allows particulate to settle by gravity to level 34 before gas 33 is driven down tubes 29 and 30 respectively. There can be as many tubes as desired to achieve the total gas flow. Level 34 is created by virtue that the gasified material 35 is moving down through the gasifier inner space generally seeking the angle of repose shown due to the chute 31 being offset from the center of the gasifier shell.

[0034] The temperature of the exit gas 36 is measured by thermocouples 37, and the speed of blower motor 24 is sufficient to pull hottest lower gases 38 at a rate up through the whole fuel mass 35 such that gases 36 and 33 are of sufficient temperature (generally over 1600 F) to be free of tars. The blower wheel (not shown) of blower 23 is cooled and steam cleaned by flows (not shown) via a double ported rotary valve 27. The temperature of gas 33 leaving the blower 23 is also

measured (sensor not shown) to insure the blower is not overheated, although as noted it is cooled by coolant flows through 27. Gasifier 16 is generally highly pressurized (although it can be an atmospheric pressure blown gasifier) and gas 36 leaves through tuyeres 39 (only one shown). The temperature of gas 36 can also be influenced or controlled by how much hot gas 33 circulates through bypass three way valves 40 and 41 respectively, thus how much enters lower tubes 44 and 45 respectively to burn in fire zone 46, increasing the temperature of the hot fire zone 46. Steam injection 47 (only one shown) can also be used to assist in controlling the temperatures of gases 33 and 36.

[0035] Three way valve 41 is inserted in rammed refractory 49 (which can alternatively be a water wall) to intersect gas flow through tubes 29 and 30 respectively. Valve 41 has an operator 50 on one end with a shaft 51 stuffing box (not shown) to accommodate the gasifier pressure. The shaft 51 is attached to sliding ceramic block 52 causing it to slide in or out horizontally as needed. Block 52 has a through opening 53 to allow gases 55 to pass through down to the lower tube area 45, but also has a wedged shaped inner end 54, which if the block 52 is pushed all the way in by operator 50, will block off all the upper gas flow 43 and all gas 33 in tube 30 flows at 55 to make a hotter fire in zone 46. The steam in gas 33 from drying fuel 1 is uniquely positioned whether as flow 43 or 55 to enhance gasification reactions in zone 46 and has the effect to reduce the steam flow 47. Thus, re-circulating gas flow 33 in this way has the effect of achieving similar gasification efficiency as if fuel 1 were dry since 30-40% of dry fuel mass 1 must be steam addition to gasify properly, and this steam is made from extra dry fuel added. Thus, fuels as wet as 40% will not appreciably affect the overall thermal efficiency of the gasifier or result in any more fuel 1 to be added on a dry measured basis (more weight of fuel 1 is of course added than dry fuel on a wet basis). Valve 40 is designed to operate the same way as 41. Since the gas is only re-circulating within the inner gasifier itself, there is minimal pressure drop across the valves to control bypass gas flows 43 and 55 respectively. Therefore, valve block 52 does not need to be a tight fit within valve 41 to perform its intended function. Generally, not over thirty to forty inches of water backpressure is expected from fire zone 46 up through hot zone 32.

[0036] For some coal fuels, the lower area of zone 18 will be where coal caking occurs, thus the lower stirrer 27 serves to break up this caking. It's in zone 18 that the volatile compounds are driven off and enter with gas flow 33 whereby temperature in this area 32 are maintained high enough to insure the gas 33 is also free of tars along with the exit gas 36, i.e. the gas 33 is at least 1600 F or higher in temperature to avoid tars in either gases 33 and 36. There are ample means to control the upper temperature of these gases 33 and 36.

[0037] Gasifier 16 as shown is a slagging gasifier, but it could be non-slagging as well using an ash unloader as described for the feed lock hopper 6 with rotating components water cooled. The slagging discharge lock hopper is not shown. The two oxidant blasts 56 and 57, respectively, are maintained of sufficient flow to maintain an exit gas 36 having a CO₂ concentration to about 5% (CO₂ measurement instrument is not shown but would be a pressure reducing gas sampling device to an atmospheric CO₂ probe taken near temperature sampling area 37) and at the least hot enough temperature in zone 46 such that slag 58 flows around baffle 59 and out tap hole 60 into a slag quenching and lock hopper (not shown). To add another degree of freedom to maintain or

control slag as molten, a water cooled copper induction coil 61 is shown mounted around the entrance of the slag hole 60, getting coolant and high frequency current in through copper tubes 62 and 63 respectively to provide extra heat energy to maintain molten conditions of slag 58. Note that blasts 56 and 57 cooperate with re-circulating gas blasts 55 to form trajectory burning zones 64 and 65 which projects the hottest fire away from the inner ends of these blast tubes or nozzles, all of which can be water cooled as necessary. The thermocouples 48 (only one shown) in zone 46 would generally be gas-cooled thermocouples with at least two installed, with one as a backup. If zone 46 is not high enough in temperature to maintain molten slag 58 conditions, flux agents can also be added with fuel 1, or as noted, the induction coil 61 can be designed into the base of the tap hole 60. The separate tube 66 denoted by a dotted line allows steam flow made from quenching the slag in the quench tank space (not shown) to be separately introduced into the void space 65 which, and due to the suction created by the high velocity flows 57 and 55, which could have adjustable nozzles, will suction this steam away from the tap hole discharge end.

[0038] While specific embodiments of the present invention have been described, it should be noted that various modifications thereto can be made without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A gasifier comprising:
 - a gasifier shell;
 - means for introducing fuel into said shell;
 - means for introducing oxygenate into said shell; and
 - means for discharging gas from said shell, wherein said means for discharging is located below said means for introducing oxygenate.
2. The gasifier of claim 1 wherein said means for discharging includes a torus shaped pipe located inside said shell and a gas exit pipe extending through said shell.
3. The gasifier of claim 2 further comprising means for directing gas into said torus shaped pipe.
4. The gasifier of claim 3 wherein said means for directing gas includes a torus shaped nose and a cone solid.
5. The gasifier of claim 1 further comprising means for discharging slag and/or ash from said shell.
6. The gasifier of claim 5 wherein said means for discharging slag and/or ash includes a tap hole formed in said shell and an inductive coil disposed around said tap hole.
7. The gasifier of claim 1 further comprising means for re-circulating gas prior to gas being discharged from said shell.
8. The gasifier of claim 7 wherein said means for re-circulating gas includes a blower located at or near the top of the shell and one or more down-flow tubes, said down-flow tubes directing gas into said means for introducing oxygenate.
9. The gasifier of claim 1 further comprising an agitator disposed in said shell.
10. A gasifier comprising:
 - a gasifier shell;
 - means for introducing fuel into said shell;
 - means for introducing oxygenate into said shell, wherein a fire zone is created in said shell adjacent to said means for introducing oxygenate;
 - means for discharging gas from said shell; and
 - means for re-circulating gas prior to gas being discharged from said shell.

11. The gasifier of claim **10** wherein said shell defines a wall and an interior, and said means for re-circulating gas includes one or more re-circulation tubes running lengthwise in said wall.

12. The gasifier of claim **11** wherein said means for re-circulating gas further includes a re-circulating blower that draws gas from said interior of said shell and into said re-circulation tubes.

13. The gasifier of claim **12** wherein said re-circulating blower is driven by a variable speed motor.

14. The gasifier of claim **11** further comprising a valve associated with each re-circulation tube, wherein said valve

can be adjusted to control how much gas from said re-circulation tube is directed into said fire zone.

15. The gasifier of claim **10** wherein said means for introducing fuel includes a chute that is offset from the center of said shell.

16. The gasifier of claim **10** further comprising an agitator disposed in said shell.

17. The gasifier of claim **10** further comprising means for discharging slag and/or ash from said shell.

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