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(54) **BULK FUELED GASIFIERS**

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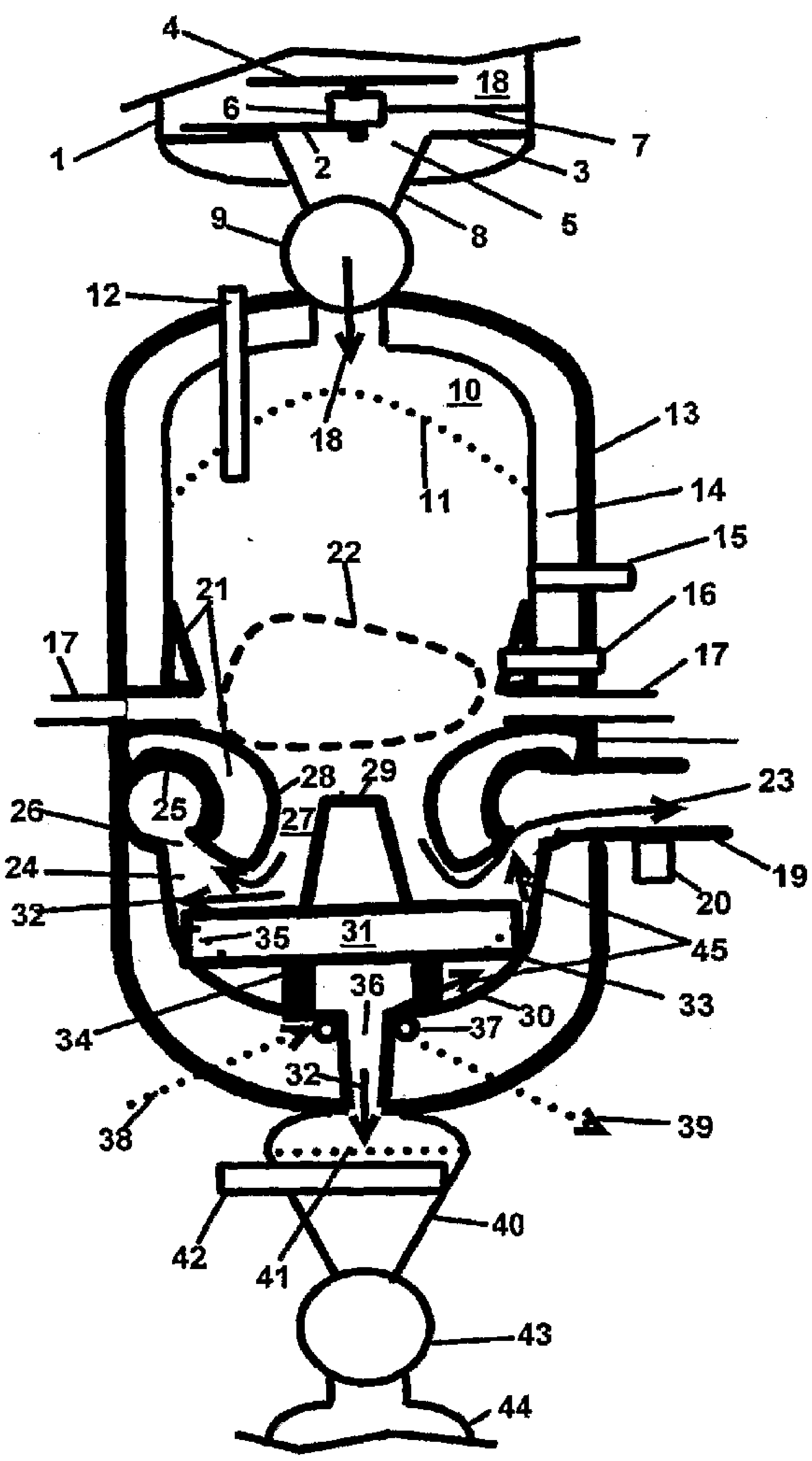
(57) **ABSTRACT**

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.



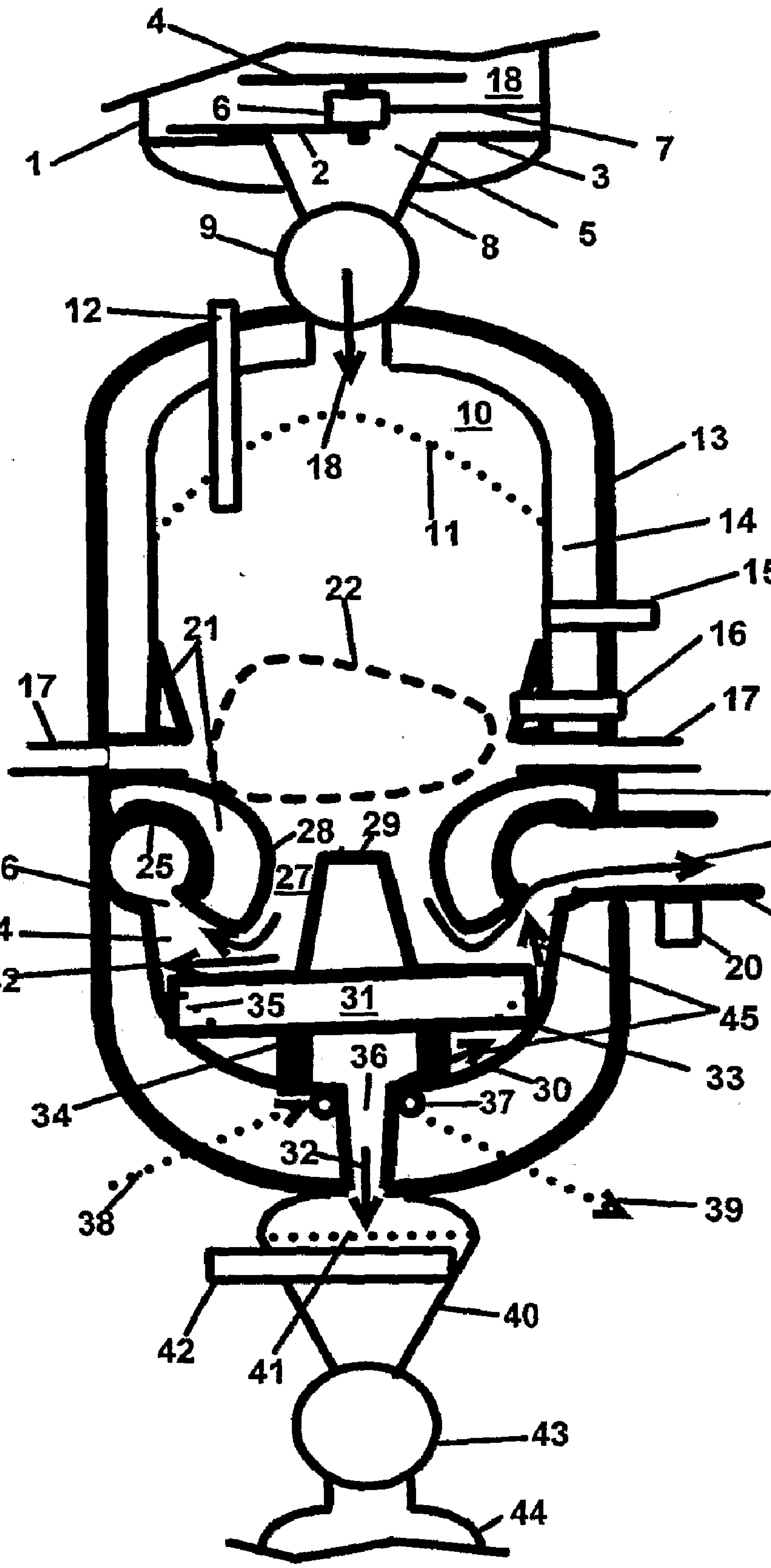

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FIG 1

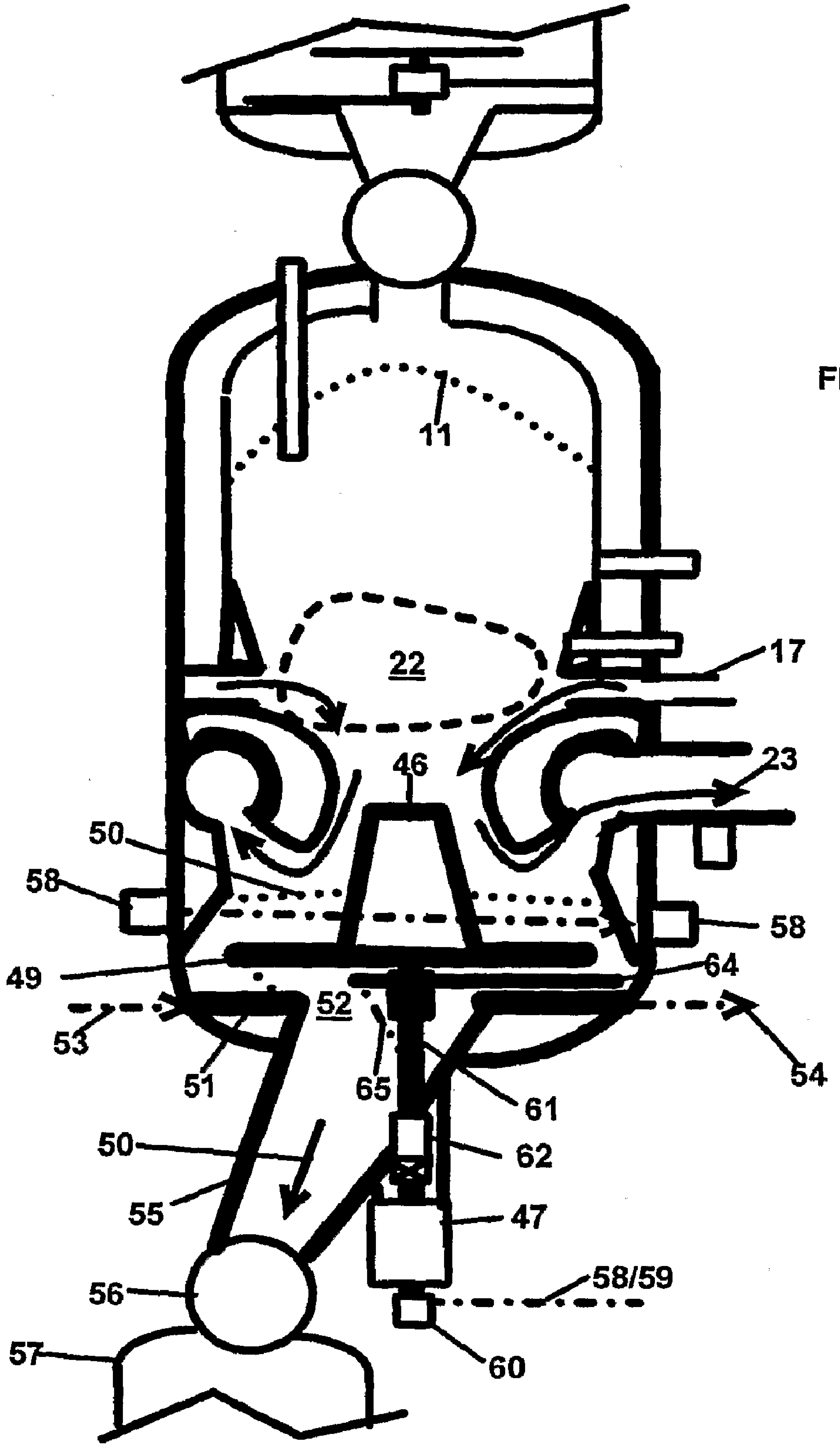
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FIG 2

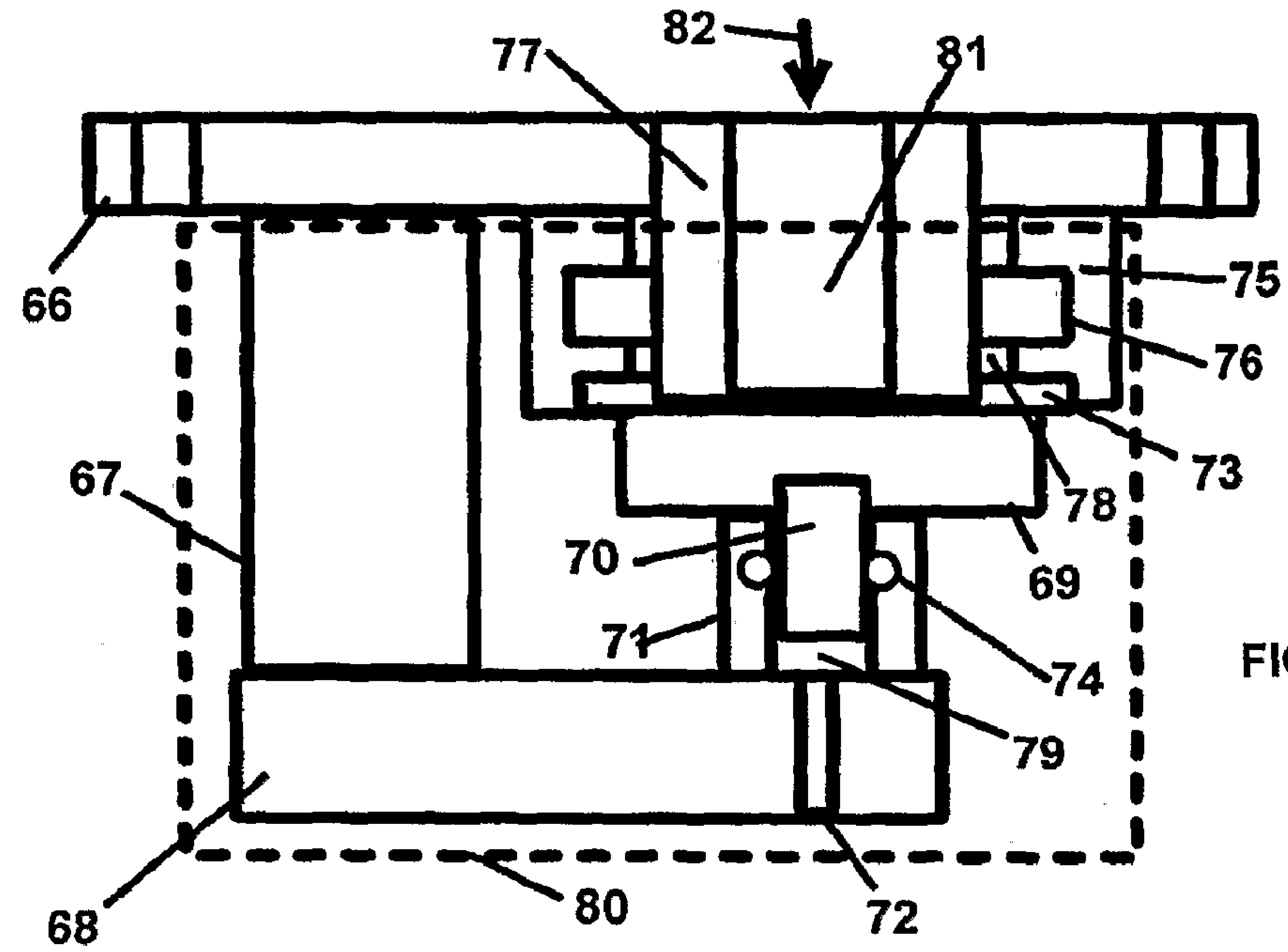
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FIG 3

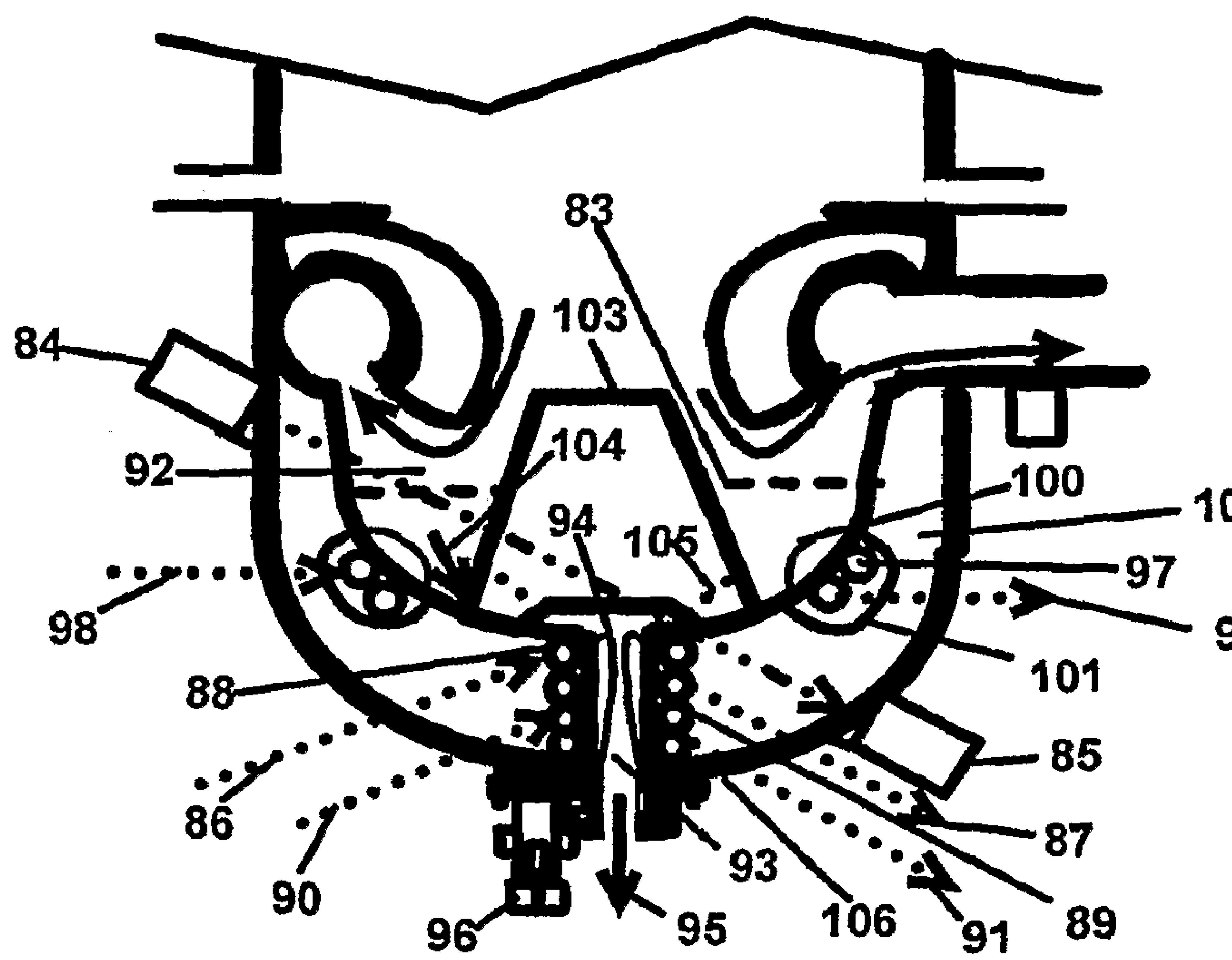
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FIG 4

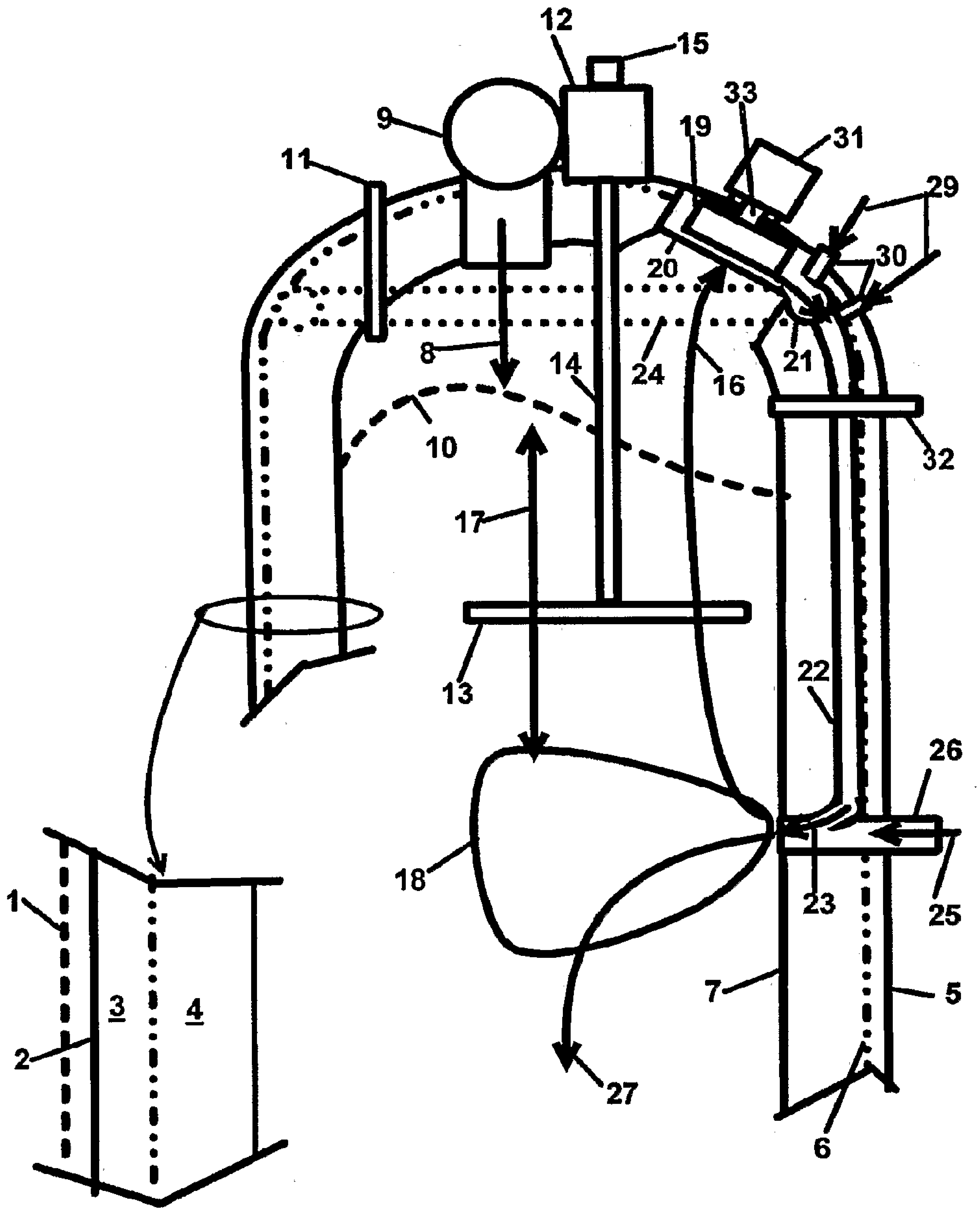

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FIG. 6

FIG. 5

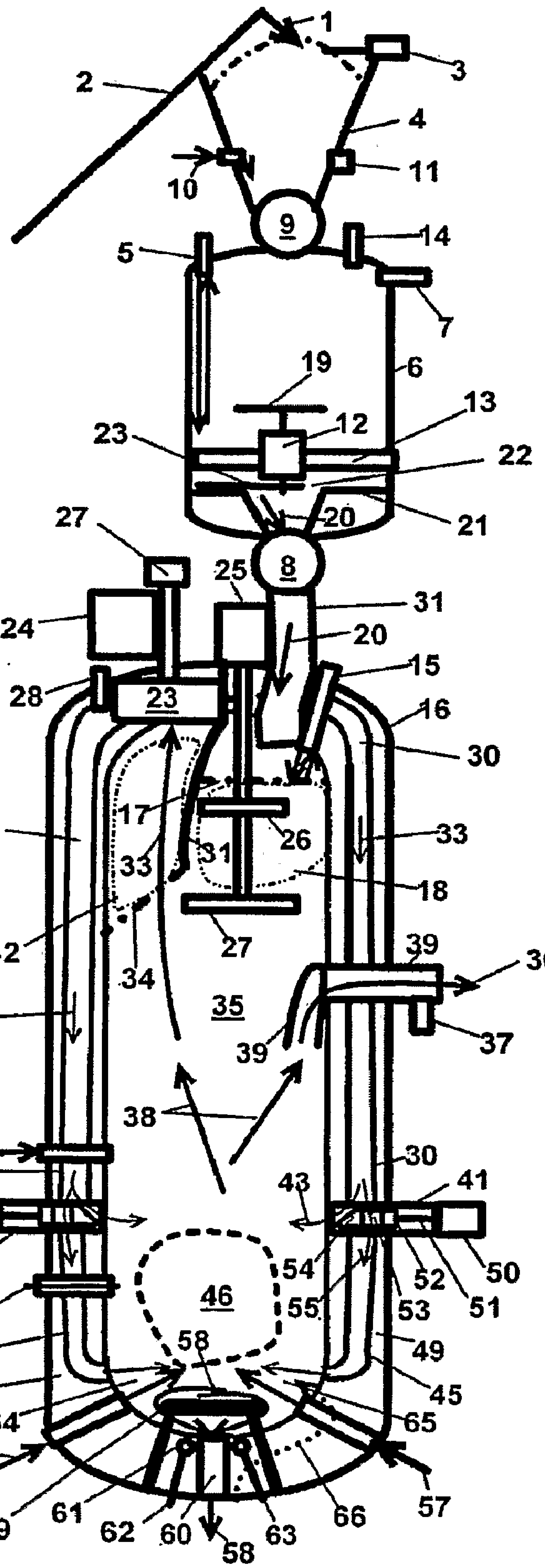
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FIG 7

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 syncrude 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., O_2 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 CO_2 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 though 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 it 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 though 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 form 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 bower 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 though 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 though 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 though 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 though 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 though **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 though 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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