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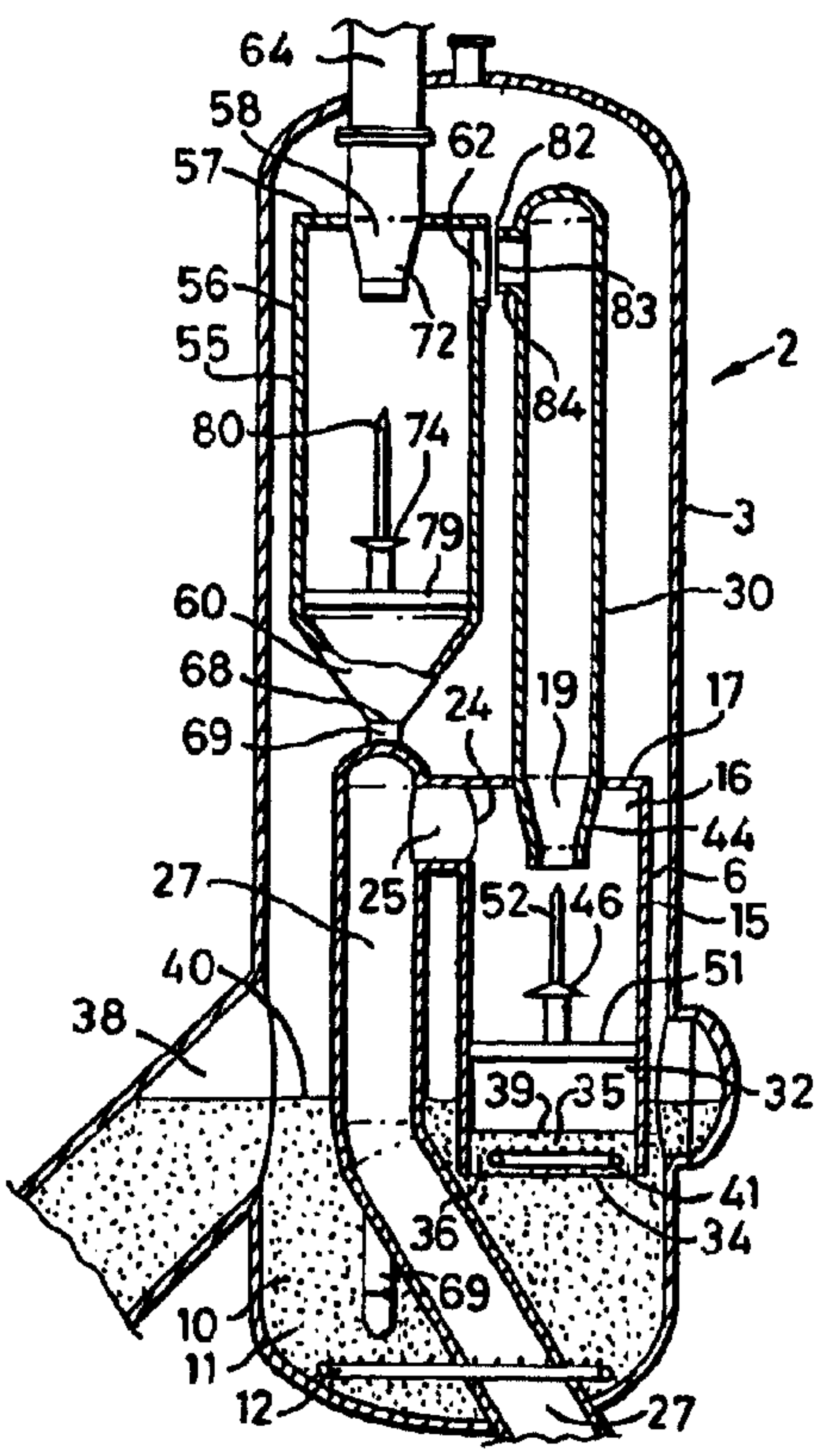
(54) Titre : APPAREIL ET PROCEDE PERMETTANT DE SEPARER ET DE RECTIFIER LESDITES PARTICULES D'HYDROCARBURES GAZEUX LES PARTICULES DE CRAQUAGE D'UN CATALYSEUR FLUIDE
(54) Title: APPARATUS AND METHOD FOR THE SEPARATION AND STRIPPING OF FLUID CATALYST CRACKING PARTICLES FROM GASEOUS HYDROCARBONS



(57) Abrégé/Abstract:
Integrated disengager and stripper (2) for separating solid particles suspended in vapour and for stripping adsorbed and entrained residue from the solid particles comprising: a disengager vessel (3) having a primary fluidized-bed zone (10), and a primary injector (12) for injecting into the primary fluidized-bed zone (10) a gas for fluidizing or stripping solid particles; a vertical primary cyclone (6),

(57) Abrégé(suite)/Abstract(continued):
which has a cylindrical side wall (15) and is closed at its upper end by means of a cover (17) provided with an outlet opening (19) and open at its lower end, which primary cyclone (6) is further provided with an inlet (24) for receiving a suspension of solid particles and vapour; and a first outlet conduit (30) for providing a flow path from the outlet opening (19) of the primary cyclone (6), wherein the open lower end (32) of the primary cyclone (6) projects downwardly into the primary fluidized-bed zone (10) so as to form a secondary fluidized-bed zone (35) within the open lower end (32) of the primary cyclone (6), and wherein suitably there is provided a secondary injector (41) for injecting into the secondary fluidized-bed zone (35) a gas for fluidizing or stripping solid particles.

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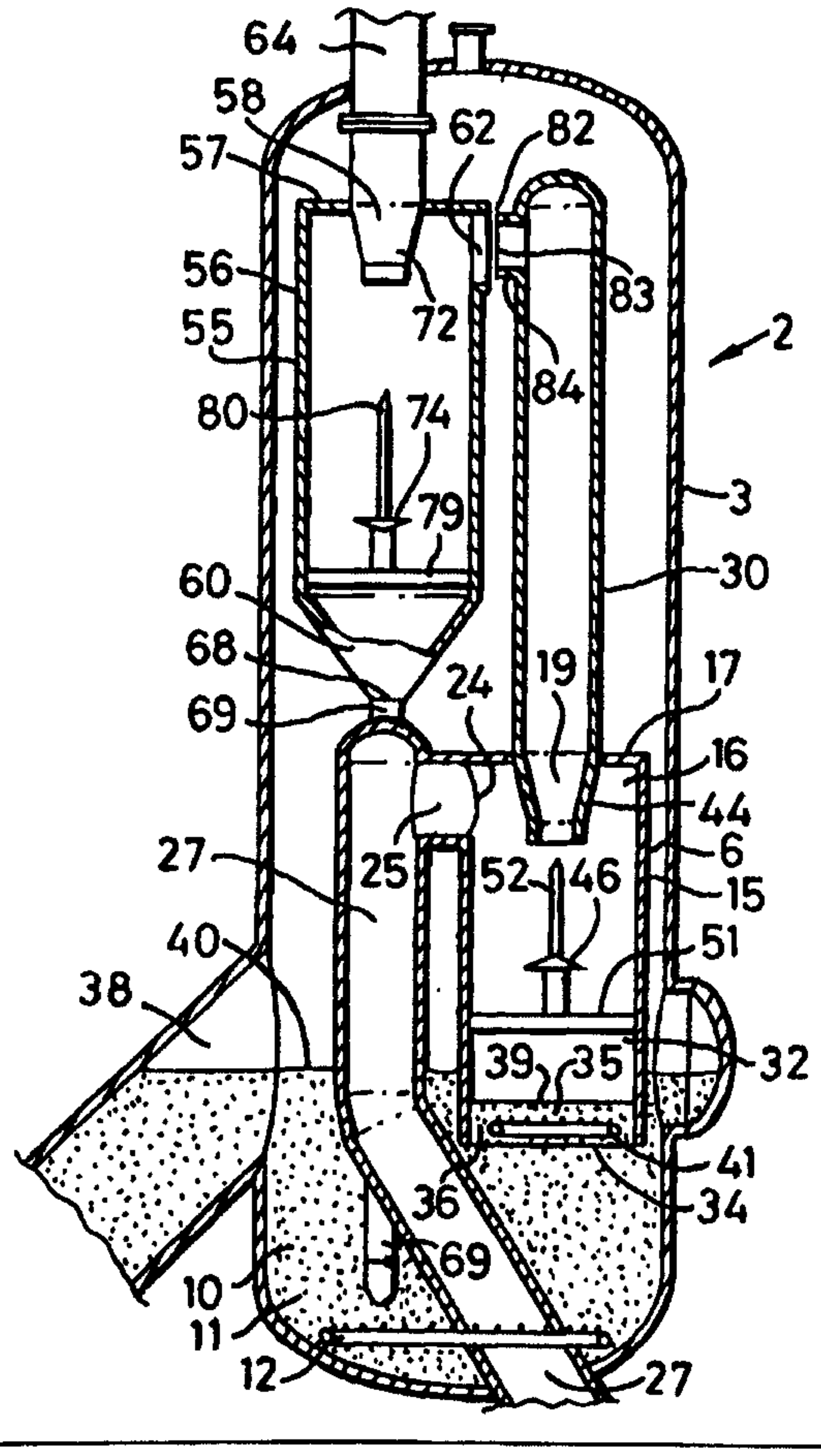
(54) Title: APPARATUS AND METHOD FOR THE SEPARATION AND STRIPPING OF FLUID CATALYST CRACKING PARTICLES FROM GASEOUS HYDROCARBONS

(57) Abstract

Integrated disengager and stripper (2) for separating solid particles suspended in vapour and for stripping adsorbed and entrained residue from the solid particles comprising: a disengager vessel (3) having a primary fluidized-bed zone (10), and a primary injector (12) for injecting into the primary fluidized-bed zone (10) a gas for fluidizing or stripping solid particles; a vertical primary cyclone (6), which has a cylindrical side wall (15) and is closed at its upper end by means of a cover (17) provided with an outlet opening (19) and open at its lower end, which primary cyclone (6) is further provided with an inlet (24) for receiving a suspension of solid particles and vapour; and a first outlet conduit (30) for providing a flow path from the outlet opening (19) of the primary cyclone (6), wherein the open lower end (32) of the primary cyclone (6) projects downwardly into the primary fluidized-bed zone (10) so as to form a secondary fluidized-bed zone (35) within the open lower end (32) of the primary cyclone (6), and wherein suitably there is provided a secondary injector (41) for injecting into the secondary fluidized-bed zone (35) a gas for fluidizing or stripping solid particles.



APPARATUS AND METHOD FOR THE SEPARATION AND STRIPPING OF FLUID CATALYST CRACKING PARTICLES FROM GASEOUS HYDROCARBONS

This invention relates to an apparatus for the separation of solid particles from gaseous hydrocarbons and stripping of hydrocarbons from the separated solid particles. In yet another aspect, it relates to an improved method for separating solid particles, such as catalyst, from gaseous hydrocarbons and stripping hydrocarbons from the separated particles.

Apparatus for separating solid particles from gaseous hydrocarbons have been available for years and have found commercial use, for instance in the separation of hydrocarbon cracking catalysts from gaseous products in a fluidized catalytic cracking process.

In a process which uses solid particles, it is common for suspensions and other mixtures of fine particles to be entrained in a gaseous stream. Many times, the suspensions contain fine solid particles which contain adsorbed and/or entrained residue of the substance(s) involved in the reaction. It becomes necessary to both separate and recover the fine particles from the gaseous stream and to strip the residue from the fine particles in order to prevent possibly detrimental or undesirable reactions downstream. For example, in a typical catalytic cracking process, hydrocarbons are reacted in the presence of catalyst in a riser reactor. Hydrocarbon gases are formed which carry fine solid particles of the catalyst along as the gases flow downstream of the reactor. The suspended catalytic particles contained adsorbed and/or entrained hydrocarbons. The catalytic particles must be separated from the gases and stripped of the hydrocarbons to prevent catalytic reactions in zones where this is undesirable (commonly called "over cracking"). Stripping also increases yield and allows the catalyst to be recycled. While the apparatus and process of the present invention will be described with particular emphasis on catalytic cracking of hydrocarbons, it is to be understood that it is not so limited and that the apparatus and processes will function as well for other systems which use solid particles and generate mixtures of the solid particles in vapour flow.

As new, highly reactive cracking catalysts, such as zeolites, came into common usage, new separation apparatus were developed to rapidly separate the reactive cracking catalyst from the cracked hydrocarbon vapour in order to avoid over cracking once the hydrocarbons exit a reactor.

USA patent specifications No. 4 961 863 and No. 5 259 855 describe a twin-drum separator which may be located at the terminal end of a catalytic cracking riser reactor. An advantage of the twin-drum separator is that it does not easily choke from catalyst carryover. Most catalytic cracking processes require a high separation efficiency in order to reduce the catalyst carried outside of the reactor vessels, and the twin-drum separator may then not be that suitable to be used alone. The twin-drum separator also does not integrate well with an internal stripper bed because the upflow of vapour from the stripper catalyst bed could disrupt the vertical flow within the twin-drum separator.

USA patent specifications No. 4 693 808 and No. 4 731 228 describe a horizontal cyclone separator. The mass ratio of catalyst to gas in a horizontal separator limits the maximum amount of catalyst the separator can carry, and if the mass ratio of catalyst to gas is too high, the horizontal cyclone separator tends to choke.

USA patent specification No. 4 692 311 describes a so-called "quick disengaging cyclone" to reduce separating and stripping time. The cyclone works on centrifugal separation and a reverse flow vortex of vapour. A vortex stabilizer is used to terminate the vortex before it reaches the bottom of the cyclone, where, if not terminated, the vortex can pick-up separated catalyst at the bottom of the cyclone and carry the catalyst back up and out through the cyclone outlet. The quick disengaging cyclone has proven to work at high efficiency; however, the unit is fairly large due to the need for an internal catalyst stripping bed and a standpipe extending from the bottom of the cyclone.

In addition to catalytic crackers, apparatus for separation and stripping are also used in fluid cokers, entrained coal gasifiers, and other industrial processes using fast-fluidized solid particles. These units may be retrofitted to achieve higher separation and stripping efficiencies in order to meet environmental and economic needs. While separator designs such as those just described have been used for retrofitting various fast-fluidized processes, their use can be limiting for retrofitting units which have limited space for placement of separators and strippers and/or which need to be retrofitted in order to increase efficiency.

In many catalytic cracking plants, for example, a riser reactor exhausts into a disengager vessel where undesirable post-riser cracking takes place. Most of these disengager vessels have a fluidized catalyst bed in the bottom and some sort of separation means at the top. These disengager vessels are often too small to be retrofitted internally with a separator and stripper such those just described. Moreover, it is expensive and inefficient to disassemble working catalytic crackers in order to install improved separators. So it has not always been possible, or desirable, to place higher-efficiency separators and strippers, such as those just described, into existing disengager vessels. It is very desirable to provide a separator and stripper technology which has high efficiency, smaller size, and simpler design.

It is an object of this invention to provide an integrated disengager and stripper which has a high separation efficiency.

It is another object of this invention to provide a retrofit integrated disengager and stripper which can fit into existing catalytic cracker disengager vessels.

It is yet another object of this invention to provide a retrofit integrated disengager and stripper which is less expensive to manufacture.

To this end the integrated disengager and stripper for separating solid particles suspended in vapour and for stripping adsorbed and entrained residue from the solid particles according to the present invention comprises:

(a) a disengager vessel having a primary fluidized-bed zone adapted to contain fluidized solid particles, and a primary means for injecting into the primary fluidized-bed zone a gas for fluidizing or stripping solid particles;

(b) a vertical primary cyclone contained inside the disengager vessel, which primary cyclone has a cylindrical side wall and is closed at its upper end by means of a cover provided with an outlet opening and open at its lower end, which primary cyclone is further provided with at least one inlet for receiving a suspension of solid particles and vapour; and

(c) a first outlet conduit for providing a flow path

from the outlet opening of the primary cyclone, which has an end connected to the outlet opening of the primary cyclone,
wherein the open lower end of the primary cyclone projects downwardly into the primary fluidized-bed zone so as to form a secondary fluidized-bed zone within the lower open end of the primary cyclone.

The invention further relates to a method for separating a mixture of solid particles and vapour and for stripping adsorbed and entrained residue from separated solid particles in a disengager vessel having a primary fluidized bed, which method according to the invention comprises:

(a) flowing a mixture of solid particles and vapour through a transport conduit;

(b) passing the mixture of solid particles and vapour from the transport conduit into a vertical primary cyclone having an open lower end contained inside the disengager vessel, wherein the open lower end of the primary cyclone is submerged in the primary fluidized bed;

(c) controlling the level of the primary fluidized bed so that the top surface of the primary fluidized bed is maintained above the open lower end of the primary cyclone, and that a portion of the primary fluidized bed is contained within the primary cyclone at the open lower end, forming a secondary fluidized bed;

(d) separating the mixture of solid particles and vapour into separated vapour and separated solid particles containing adsorbed or entrained residue;

(e) collecting the separated solid particles in the secondary fluidized bed contained within the primary cyclone;

(f) introducing a gas to strip the residue from the separated solid particles, forming stripped vapours and

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stripped solid particles;

(g) allowing the separated vapour and stripped vapour to pass upwards through the primary cyclone; and

(h) allowing stripped solid particles to flow away from the open lower end of the primary cyclone into the primary fluidized bed.

The invention will now be described by way of example with reference to the drawings, wherein

Figure 1 shows a cross-sectional view of the integrated disengager and stripper according to the present invention;

Figure 2 shows a cross-sectional view of the primary cyclone of Figure 1 drawn to a scale larger than that of Figure 1; and

Figure 3 shows a cross-sectional view of the secondary cyclone of Figure 1 drawn to a scale larger than that of Figure 1.

Reference is now made to Figures 1 and 2. The integrated disengager and stripper 2 for separating solid particles suspended in vapour and for stripping adsorbed and entrained residue from the solid particles according to the present invention comprises a disengager vessel 3 and a vertical primary cyclone 6 which is contained inside the disengager vessel 3.

The disengager vessel 3 has a primary fluidized-bed zone 10 adapted to contain a primary fluidized bed 11 of fluidized solid particles, and a primary means for injecting into the primary fluidized-bed zone a gas for fluidizing or stripping solid particles in the form of primary injector 12.

The vertical primary cyclone 6 has a cylindrical wall in the form of circle-cylindrical side wall 15 and is closed at its upper end 16 by means of a cover 17 provided with an outlet opening 19.

The primary cyclone 6 is further provided with at least one inlet 24 for receiving a suspension of solid particles and vapour. The inlet 24 of the primary cyclone is directly connected to an outlet conduit 25 of a transport conduit in the form of a reactor riser 27 extending into the disengager vessel 3.

The integrated disengager and stripper 2 also comprises a first outlet conduit 30 for providing a flow path from the outlet opening 19 of the primary cyclone 6, which has an end that is connected to the outlet opening 19 of the primary cyclone 6.

The vertical primary cyclone 6 is closed at its upper end 16, however, it is open at its lower end 32 having a discharge opening 34, wherein the inner diameter of the open lower end 32 is substantially equal to that of the upper end 16 of the primary cyclone 6. The open lower end 32 of the vertical primary cyclone 6 projects downwardly into the primary fluidized-bed zone 10 so as to form a secondary fluidized-bed zone 35 adapted to contain during normal operation a secondary fluidized bed 36 of fluidized solid particles within the lower end 32 of the primary cyclone 6.

During normal operation, a mixture of solid particles in the form of catalyst particles and vapour in the form of reaction effluent from a catalytic cracking process flows upwards through the reactor riser 27, and passes through its outlet conduit 25 into the inlet 24 of the primary cyclone 6.

In the primary cyclone 6 the catalyst particles are separated from the reaction effluent; the catalyst particles fall downwards towards the lower end 32 of the primary cyclone 6, and the reaction effluent passes upwards and leaves the primary cyclone 6 through the first outlet conduit 30.

The lower part of the disengager vessel 3 contains the primary fluidized bed 11 of catalyst particles which are maintained in a fluidized state by the action of gas for fluidizing solid particles injected into the primary fluidized-bed zone 10 through the primary injector 12. The gas also strips the catalyst particles and in this way adsorbed or entrained residue are removed therefrom to obtain stripped catalyst particles which are discharged from the disengager vessel 3 through discharge conduit 38. The catalyst particles are passed to a regenerator (not shown) where they are regenerated so that they can be used in the reactor riser 27.

Since the open lower end 32 of the primary cyclone 6 projects downwardly into the primary fluidized-bed zone 10, the discharge opening 34 is submerged in the primary fluidized bed 11, and the level of the primary fluidized bed 11 is controlled so that the top surface 39 of the primary fluidized bed 11 is maintained above the discharge opening 34 of the primary cyclone 3. The portion of the primary fluidized bed 11 contained within the lower end 32 of the primary cyclone 6 forms the secondary fluidized bed 36.

The separated catalyst particles which fall downwardly through the primary cyclone 6 are collected in the secondary fluidized bed 36.

Gas introduced through the primary injector 12 also enters into the secondary fluidized bed 36 to strip the residue from the separated catalyst particles, forming stripped vapour and stripped catalyst particles. The stripped vapour and removed reaction effluent pass upwards through the primary cyclone 6, and are removed through the first outlet conduit 30. Whereas stripped catalyst particles are allowed to flow away from the discharge opening 34 of the primary cyclone 6 into the primary fluidized bed 11.

The fluidized catalyst particles are thus partially contained in the secondary fluidized bed 36 inside the open lower end 32 of the primary cyclone 6. This secondary fluidized bed 36 acts as a quick-stripper fluidized stripper bed inside the primary cyclone 6 while the primary fluidized bed 11 acts as a main-stripper fluidized stripper bed inside the disengager vessel 3. Therefore the fluidized-bed zones are sometimes also called stripper zones.

Suitably the primary cyclone 6 is operated at a slightly higher pressure than that in the disengager vessel 3, so that the top surface 39 of the secondary fluidized bed 36 is below the top surface 40 of the primary fluidized bed 11.

A conventional primary cyclone is normally closed at its lower end, and provided with a dip-leg to release separated solid particles, such as catalyst, which builds up in the bottom of the primary cyclone. In order to develop sufficient head to overcome the cyclone inlet and outlet pressure drop and thus to allow the separated solid particles to discharge to a fluidized bed, there usually must be a relatively long dip-leg. Thus, the entire apparatus requires substantial space to accommodate the length. However, the primary cyclone according to the present invention does not require a dip-leg and thus can be made to fit into a disengager vessel with limited space. The known system also experience problems during start-up when slugs of catalyst particles flow up the transport conduit with the mixture of vapour and catalyst particles. The excess particles fall into the primary cyclone and fill it. To solve this problem, many operators do not place any catalyst into the primary cyclone or in the disengager vessel at start-up. Of course, this decreases both yield and efficiency until the catalyst level is adequate to accommodate the necessary stripping step. In the present invention, any slugs formed during start-up fall into the

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open-ended primary cyclone, and they are fluidized away from the open lower end 32 and distributed in the primary fluidized bed in the disengager vessel, eliminating unwanted build-up in the primary cyclone.

Suitably, the integrated disengager and stripper further comprises secondary means for injecting into the secondary fluidized-bed zone 35 a gas for fluidizing or stripping solid particles in the secondary fluidized bed 36 in the form of secondary injector 41.

The inlet 24 of the primary cyclone 6 is suitably a tangential inlet 42 (see Figure 2) arranged in the circle-cylindrical side wall 15 near the closed end of the primary cyclone 6. The mixture of mixture of solid particles in the form of catalyst particles and vapour in the form of reaction effluent from a catalytic cracking process entering through the tangential inlet 42 of the primary cyclone 6, is caused to form a vortex in the upper end 16 of the primary cyclone 6. The upper end 16 is then the swirl zone of the primary cyclone 6.

The efficiency of the swirl zone can be improved when part 44 of the first outlet conduit 30 extends into the primary cyclone 6. Part 44 forms the vortex outlet of the primary cyclone 6.

Suitably the primary cyclone 6 further comprises a primary dish-shaped vortex stabilizer 46 coaxially mounted in the middle part 47 of the primary cyclone 6. The outer diameter of the primary vortex stabilizer 46 is equal to or larger than the diameter of the first outlet conduit 30, and smaller than the inner diameter of the circle-cylindrical side wall 15.

The primary vortex stabilizer 46 is positioned below the inlet opening 49 of the first outlet conduit 30, and suitably at a distance which is equal to or larger than the diameter of the first outlet conduit 30. In the embodiment of the invention as shown in Figure 1 and 2, the first outlet conduit has a tapered part 44, and the diameter is the smallest diameter of the tapered part 44.

When a vortex stabilizer is used, the depth to which the discharge opening 34 of the primary cyclone 6 is submerged in the primary fluidized bed 11 is dependent upon the elevation of the vortex stabilizer. In particular, the depth of the secondary fluidized bed 36 should not be larger than the distance from the discharge opening 34 of the primary cyclone 6 to the bottom of the primary vortex stabilizer 46. In the embodiment which uses a vortex stabilizer such as that shown in Figures 1 and 2, the maximum depth of the secondary fluidized bed 36 would be from the discharge opening 34 of the primary cyclone 6 to the bottom most surface of the primary vortex stabilizer 46.

The primary vortex stabilizer 46 is supported by means of supports 51. It is suitably provided with a vortex finder 52.

The annular space between the outer surface of the primary vortex stabilizer 46 and the inner surface of the cylindrical side wall 15 allows separated particles to pass downward through the annular space into the secondary fluidized-bed zone 35. The annular space also allows stripping gas from the fluidized-bed zone to pass upward through the annular space into the cyclone zone above the primary vortex stabilizer 46. The secondary fluidized-bed zone 35 defines a stripping zone in gaseous communication with the cyclone zone in the upper end 16 through the annular space. In the fluidized-bed zone, adsorbed and/or entrained residue is stripped from the particles to thereby recover the residue and to reduce undesired reactions of the residue. For example, in a suspension of fine catalyst particles and hydrocarbon vapours, the hydrocarbon vapours are first separated from the catalyst particles in the cyclone zone. Then the adsorbed and entrained hydrocarbon on the catalyst is stripped from the catalyst in the fluidized-bed zone, recovering the hydrocarbon as hydrocarbon vapour and reducing undesired over cracking reactions.

In a suitable embodiment, the integrated disengager and stripper 2 according to the present invention further comprises a secondary cyclone 55 contained within the disengager vessel 3, having a cylindrical side wall in the form of circle-cylindrical side wall 56. The secondary cyclone 55 is closed at its upper end by means of a cover 57 provided with an outlet opening 58. It comprises a lower portion 60 and an inlet 62 which is in fluid communication with the first outlet conduit 30. The integrated disengager and stripper 2 also includes a second outlet conduit 64 providing a flow path from the outlet opening 58 of the secondary cyclone 55.

During normal operation, separated vapour and stripped vapour are removed from the primary cyclone 6 through the first outlet conduit 30. This vapour still contains entrained catalyst particles which have to be removed in the secondary cyclone 55. To this end the vapour is introduced into the secondary cyclone 55, entrained catalyst particles are separated from the vapour. The vapour is flows upwards in the secondary cyclone 55 through the outlet opening 58, and the catalyst particles are collected in the lower portion 60 of the secondary cyclone 55. Vapour and catalyst particles are discharged separately from the secondary cyclone 55, through the second outlet conduit 64 and an outlet opening 68 in the lower portion 60, respectively. The secondary cyclone 55 is operated at a pressure which is slightly below that in the primary cyclone 6, and since that pressure is below that in the disengager vessel 3, the pressure in the secondary cyclone 55 is lower than that in the disengager vessel 3.

The secondary cyclone 55 is suitably provided with a dip-leg 69. The dip-leg 69, which is preferably provided with a valve (not shown) at the bottom to allow release of separated particles, extends into the primary fluidized bed 11.

The secondary cyclone 55 is placed in series with the primary cyclone 6, which is called in the art "close-coupling". The term "close-coupled" is commonly used when the exhaust of one cyclone is coupled to the inlet of another cyclone. Close-coupling cyclones reduces the undesirable, post-riser cracking of riser reactor products which can take place when, for example, (1) all separation is performed in the disengager vessel, or (2) the first cyclone exhausts into the disengager vessel.

When both a primary cyclone with vortex stabilizer means and a secondary cyclone with vortex stabilizer means are used in series, the primary cyclone acts as a "quick disengaging cyclone" and the secondary cyclone acts as a "high efficiency cyclone."

Suitably the inlet 62 of the secondary cyclone 55 is a tangential inlet 70 (see Figure 3) arranged in the upper end 71 of the secondary cyclone 55. Vapour and catalyst particles entering through the tangential inlet 70 of the secondary cyclone 55, are caused to form a vortex in the upper end 71 of the secondary cyclone 55. The upper end 71 is then the swirl zone of the secondary cyclone 55.

The efficiency of the swirl zone can be improved when part 72 of the second outlet conduit 64 extends into the secondary cyclone 55. Part 72 forms the vortex outlet of the secondary cyclone 55.

Suitably the secondary cyclone 55 further comprises a secondary dish-shaped vortex stabilizer 74 coaxially mounted in the middle part 76 of the secondary cyclone 55. The outer diameter of the secondary vortex stabilizer 74 is equal to or larger than the diameter of the second outlet conduit 64, and smaller than the inner diameter of the circle-cylindrical side wall 56. The secondary vortex stabilizer 74 is positioned below the inlet opening 77 of the second outlet conduit 64 at a distance which is equal to or larger than the diameter of the second outlet conduit 64. In the embodiment of the invention as shown in Figure 1 and 3, the second outlet conduit 64 has a tapered part 72, and the diameter is the smallest diameter of the tapered part 72.

The secondary vortex stabilizer 74 is supported by means of supports 79. It is suitably provided with a vortex finder 80.

Any means for compensating for thermal and vibrational movement between the primary and secondary cyclones 6 and 55 may be used in the connection between them. In the embodiment of Figure 1, there is provided a gap 82, between the outlet 83 of the first outlet conduit 30 and the inlet 62 of the secondary cyclone 55. The gap 82 further provides a means for stripper gas and stripped vapour in the disengager vessel 3 to enter the slightly lower pressure secondary cyclone 55.

Suitably the integrated disengager and stripper according to the present invention further comprising a venturi (not shown) positioned in the outlet end 84 of the first outlet conduit 30 in the vicinity of the inlet 62 of the secondary cyclone 55. The venturi not only helps move the gases in the first outlet conduit 30 into the secondary cyclone 55, it also reduces the pressure differential between the interior of the disengager vessel 3 and the secondary cyclone 55.

Suitably the inner surfaces of the circle-cylindrical side walls 15 and 56 of the primary and secondary cyclones 6 and 55 are lined with a refractory which is resistant to erosion, such as ceramic. This allows the shell of the disengager vessel 3 to be used without a refractory lining since the cyclones are lined. The lining is not needed in the disengager vessel 3 because the solid particles will not be flowing in the disengager vessel 3 in a manner which would erode the walls. Eliminating the lining in the disengager vessel 3 reduces the occurrence of two problems commonly seen. First, corrosion caused by uneven heating of the disengager vessel walls should be reduced. Second, the refractory lining in the disengager vessel 3 will spall over time. The spalled lining enters the system, where it will plug valves and equipment. Eliminating the refractory lining of the disengager vessel 3 should substantially reduce this problem.

The combination of the primary and secondary cyclones 6 and 55 can suitably be used as a retrofit for fluid catalytic crackers, fluid cokers, entrained coal gasifiers, and other industrial processes with small disengager vessels or small internal cyclones.

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NEW CLAIMS

1. Integrated disengager and stripper (2) for separating solid particles suspended in vapour and for stripping adsorbed and entrained residue from the solid particles comprising:
(a) a disengager vessel (3) having a primary fluidized-bed zone (10) adapted to contain fluidized solid particles, and a primary means (12) for injecting into the primary fluidized-bed zone (10) a gas for fluidizing or stripping solid particles;
(b) a vertical primary cyclone (6) contained inside the disengager vessel (3), which primary cyclone (6) has a cylindrical side wall (15) and is closed at its upper end by means of a cover (17) provided with an outlet opening (19) and open at its lower end, which primary cyclone (6) is further provided with at least one inlet (24) for receiving a suspension of solid particles and vapour; and
(c) a first outlet conduit (30) for providing a flow path from the outlet opening (19) of the primary cyclone, which has an end connected to the outlet opening (19) of the primary cyclone (6),
characterized in that the open lower end of the primary cyclone (6) projects downwardly into the primary fluidized-bed zone (10) so as to form a secondary fluidized-bed zone (35) within the lower open end (32) of the primary cyclone (6).

2. Integrated disengager and stripper (2) as claimed in claim 1, further comprising secondary means (41) for injecting into the secondary fluidized-bed zone (35) a gas for fluidizing or stripping solid particles.

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3. Integrated disengager and stripper (2) as claimed in claim 1 or 2, characterized in that the inlet (24) of the primary cyclone (6) is a tangential inlet (42) arranged in the side wall (15) near the closed end of the primary cyclone (6).

4. Integrated disengager and stripper (2) as claimed in any one of the claims 1-3, characterized in that part (44) of the first outlet conduit (30) extends into the primary cyclone (6).

5. Integrated disengager and stripper (2) as claimed in any one of the claims 1-4, characterized in that the primary cyclone (6) further comprises a primary vortex stabilizer (46) coaxially mounted in the middle part of the primary cyclone (6), the outer diameter of the primary vortex stabilizer (46) being equal to or larger than the diameter of the first outlet conduit (30), which primary vortex stabilizer (46) is positioned below the inlet opening (49) of the first outlet conduit (30) at a distance which is equal to or larger than the diameter of the first outlet conduit (30).

6. Integrated disengager and stripper (2) as claimed in any one of the claims 1-5, further comprising:

(a) a secondary cyclone (55) contained within the disengager vessel (3), which secondary cyclone (55) is closed at its upper end by means of a cover (57) provided with an outlet opening (58) and comprises a lower portion (60) and an inlet (62) which is in fluid communication with the first outlet conduit (30); and

(b) a second outlet conduit (64) providing a flow path from the outlet opening (58) of the secondary cyclone (55).

7. Integrated disengager and stripper (2) as claimed in claim 6, characterized in that the inlet (62) of the secondary cyclone (55) is a tangential inlet (70)

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arranged in the upper portion (71) of the secondary cyclone (55).

8. Integrated disengager and stripper (2) as claimed in claim 6 or 7, characterized in that part of the second outlet conduit (64) extends into the secondary cyclone (55).

9. Integrated disengager and stripper (2) as claimed in any one of the claims 6-8, characterized in that the secondary cyclone (55) further comprises a secondary vortex stabilizer (74) coaxially mounted in the middle part of the secondary cyclone (55), the outer diameter of the secondary vortex stabilizer (74) being equal to or larger than the diameter of the second outlet conduit (64), which secondary vortex stabilizer (74) is positioned below the inlet opening (77) of the second outlet conduit (64) at a distance which is equal to or larger than the diameter of the second outlet conduit (64).

10. Integrated disengager and stripper (2) as claimed in any one of the claims 6-9, further comprising a venturi positioned in the outlet end (84) of the first outlet conduit (30) in the vicinity of the inlet (62) of the secondary cyclone (55).

11. Integrated disengager and stripper as claimed in any one of the claims 6-10, characterized in that there is a gap (82) between the outlet end (83) of the first outlet conduit (30) and the inlet (62) of the secondary cyclone (55).

12. Method for separating a mixture of solid particles and vapour and for stripping adsorbed and entrained residue from separated solid particles in a disengager vessel (3) having a primary fluidized bed (10) comprising:

(a) flowing a mixture of solid particles and vapour through a transport conduit (27);

(b) passing the mixture of solid particles and vapour from the transport conduit (27) into a vertical primary cyclone (6) having an open lower end contained inside the disengager vessel (3), wherein the open lower end of the primary cyclone (6) is submerged in the primary fluidized bed (10),

(c) controlling the level of the primary fluidized bed so that the top surface of the primary fluidized bed is maintained above the open lower end of the primary cyclone, and that a portion of the primary fluidized bed is contained within the primary cyclone at the open lower end, forming a secondary fluidized bed (36);

(d) separating the mixture of solid particles and vapour into separated vapour and separated solid particles containing adsorbed or entrained residue;

(e) collecting the separated solid particles in the secondary fluidized bed (36) contained within the primary cyclone (6);

(f) introducing a gas to strip the residue from the separated solid particles, forming stripped vapours and stripped solid particles;

(g) allowing the separated vapour and stripped vapour to pass upwards through the primary cyclone (6); and

(h) allowing stripped solid particles to flow away from the open lower end of the primary cyclone (6) into the primary fluidized bed (10).

13. The method as claimed in claim 12, further comprising operating the primary cyclone (6) at a slightly higher pressure than that in the disengager vessel (3), so that the top surface (39) of the secondary fluidized bed (36) is below the top surface (40) of the primary fluidized bed (10).

14. The method as claimed in claim 12 or 13, further comprising removing the separated vapour and stripped vapour to pass upwards from the primary cyclone (6),

introducing the vapour into a secondary cyclone (55), separating entrained solid particles in the secondary cyclone (55) and discharging the vapour and the solid particles separately from the secondary cyclone (55).

15. The method as claimed in any one of the claims 12-14, characterized in that the secondary cyclone (55) is operated at a pressure which is slightly below that in the primary cyclone (6).

16. Method for retrofitting an existing disengager vessel (3) having some sort of separation means at the top and a fluidized-bed zone at the bottom, hereinafter referred to as the primary fluidized-bed zone (10), adapted to contain fluidized solid particles, and a primary means (12) for injecting into the primary fluidized-bed zone (10) a gas for fluidizing or stripping solid particles, characterized in that the retrofitting is performed by placing a vertical primary cyclone (6) inside the disengager vessel (3), which primary cyclone (6) has a cylindrical side wall (15) and is closed at its upper end by means of a cover (17) provided with an outlet opening (19) and open at its lower end, which primary cyclone (6) is further provided with at least one inlet (24) for receiving a suspension of solid particles and vapour; and a first outlet conduit (30) for providing a flow path from the outlet opening (19) of the primary cyclone, which has an end connected to the outlet opening (19) of the primary cyclone (6), wherein the open lower end of the primary cyclone (6) projects downwardly into the primary fluidized-bed zone (10) so as to form a secondary fluidized-bed zone (35) within the lower open end (32) of the primary cyclone (6).

17. Method for retrofitting as claimed in claim 16, characterized in that secondary means (41) for injecting into the secondary fluidized-bed zone (35) a gas for fluidizing or stripping solid particles are present.

18. Method for retrofitting as claimed in claim 16 or 17, characterized in that the inlet (24) of the primary cyclone (6) is a tangential inlet (42) arranged in the side wall (15) near the closed end of the primary cyclone (6).

19. Method for retrofitting as claimed in any one of the claims 16-18, characterized in that part (44) of the first outlet conduit (30) extends into the primary cyclone (6).

20. Method for retrofitting as claimed in any one of the claims 16-19, characterized in that the primary cyclone (6) further comprises a primary vortex stabilizer (46) coaxially mounted in the middle part of the primary cyclone (6), the outer diameter of the primary vortex stabilizer (46) being equal to or larger than the diameter of the first outlet conduit (30), which primary vortex stabilizer (46) is positioned below the inlet opening (49) of the first outlet conduit (30) at a distance which is equal to or larger than the diameter of the first outlet conduit (30).

21. Method for retrofitting as claimed in any one of the claims 16-20, characterized in that

(a) a secondary cyclone (55) is contained within the resulting disengager vessel (3), which secondary cyclone (55) is closed at its upper end by means of a cover (57) provided with an outlet opening (58) and comprises a lower portion (60) and an inlet (62) which is in fluid communication with the first outlet conduit (30); and

(b) a second outlet conduit (64) providing a flow path from the outlet opening (58) of the secondary cyclone (55).

22. Method for retrofitting as claimed in claim 21, characterized in that the inlet (62) of the secondary

cyclone (55) is a tangential inlet (70) arranged in the upper portion (71) of the secondary cyclone (55).

23. Method for retrofitting as claimed in claim 21 or 22, characterized in that part of the second outlet conduit (64) extends into the secondary cyclone (55).

24. Method for retrofitting as claimed in any one of the claims 21-23, characterized in that the secondary cyclone (55) further comprises a secondary vortex stabilizer (74) coaxially mounted in the middle part of the secondary cyclone (55), the outer diameter of the secondary vortex stabilizer (74) being equal to or larger than the diameter of the second outlet conduit (64), which secondary vortex stabilizer (74) is positioned below the inlet opening (77) of the second outlet conduit (64) at a distance which is equal to or larger than the diameter of the second outlet conduit (64).

25. Method for retrofitting as claimed in any one of the claims 21-24, further comprising a venturi positioned in the outlet end (84) of the first outlet conduit (30) in the vicinity of the inlet (62) of the secondary cyclone (55).

26. Method for retrofitting as claimed in any one of the claims 21-25, characterized in that there is a gap (82) between the outlet end (83) of the first outlet conduit (30) and the inlet (62) of the secondary cyclone (55).

27. Method for retrofitting as claimed in any one of the claims 16-26, characterized in that the disengager vessel is used in a fluid catalytic catalyst cracker, a fluid coker or an entrained coal gasifier process.

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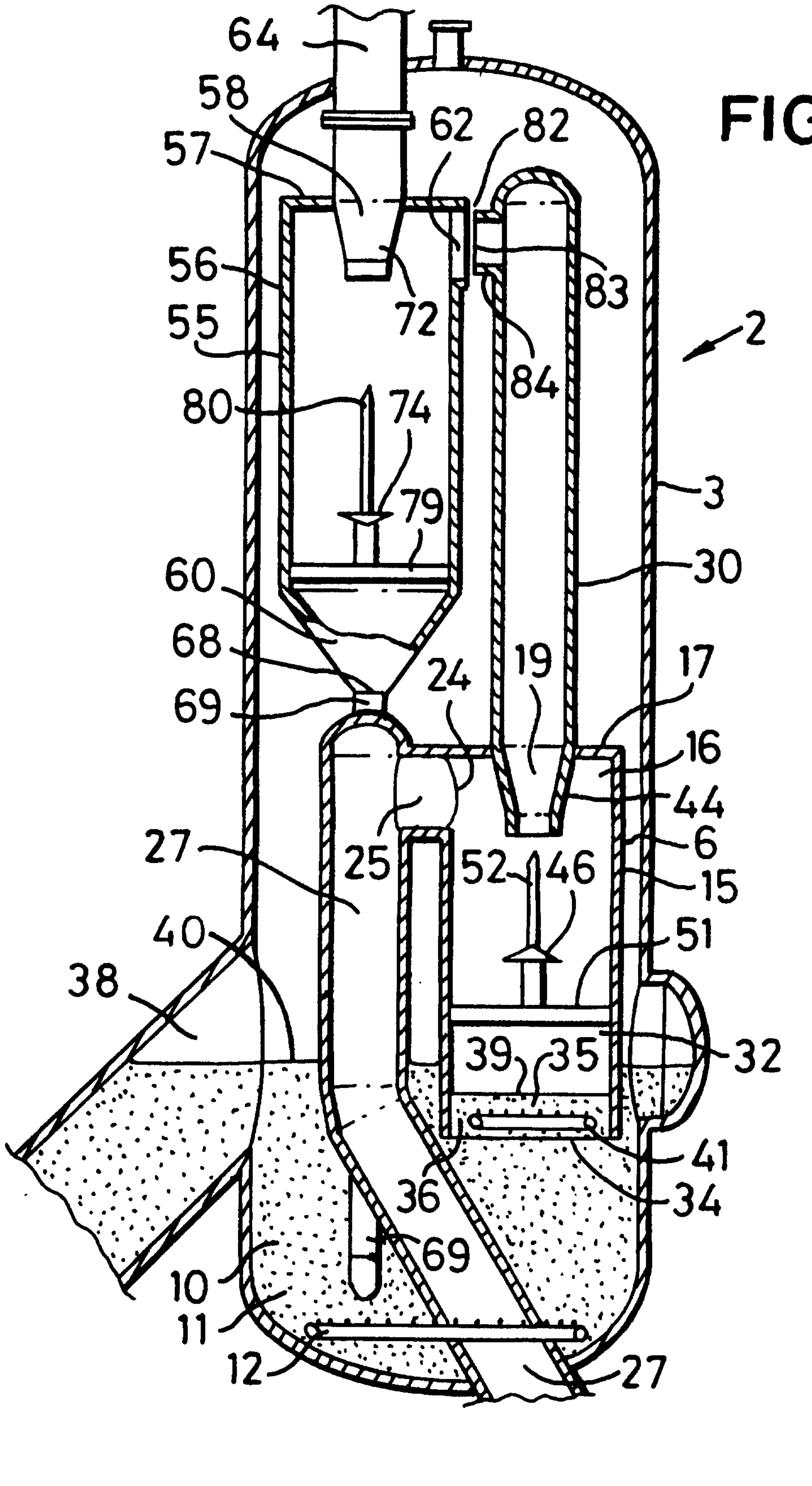
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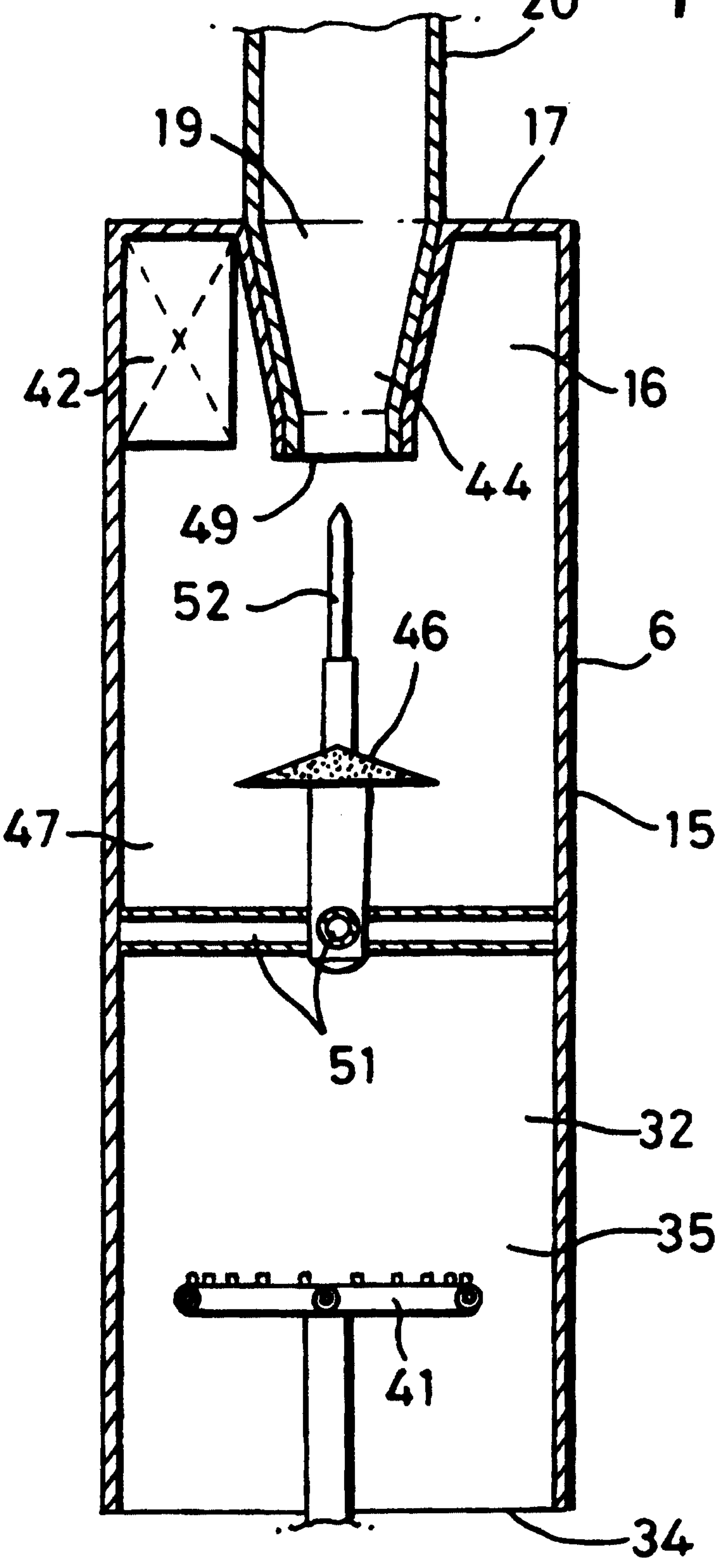
FIG.1

FIG.2



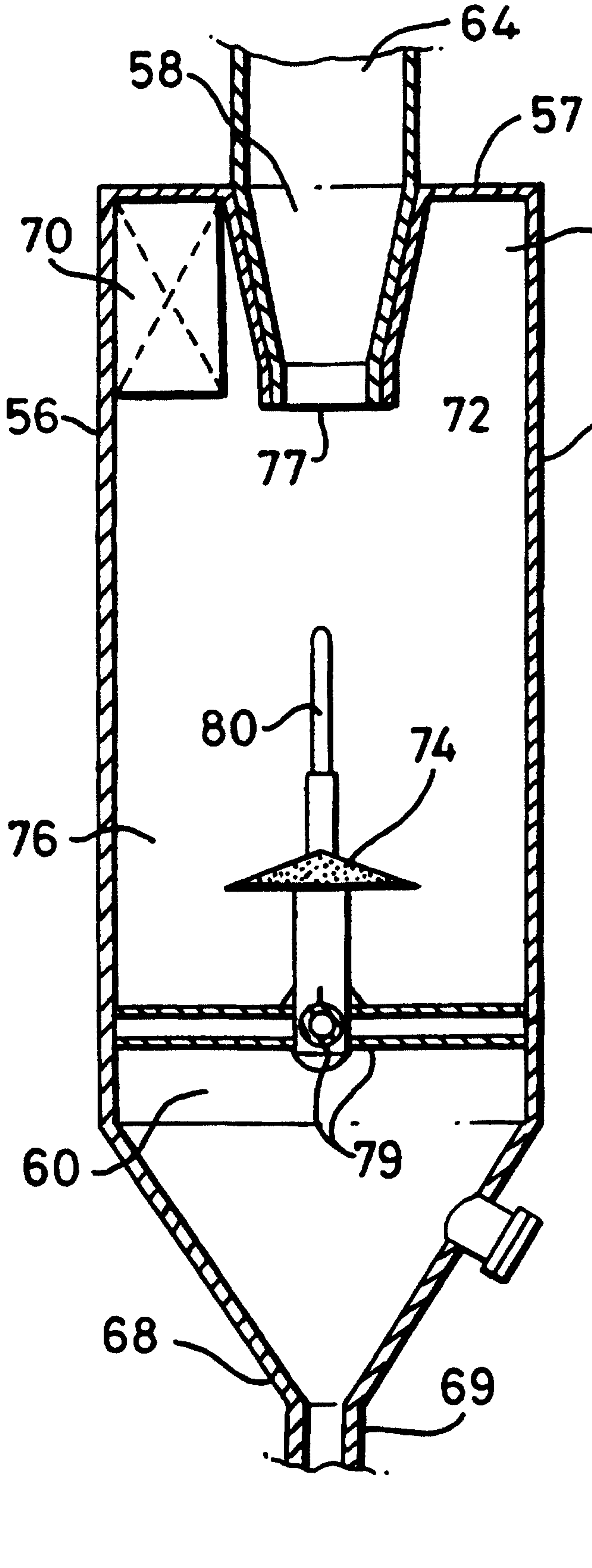
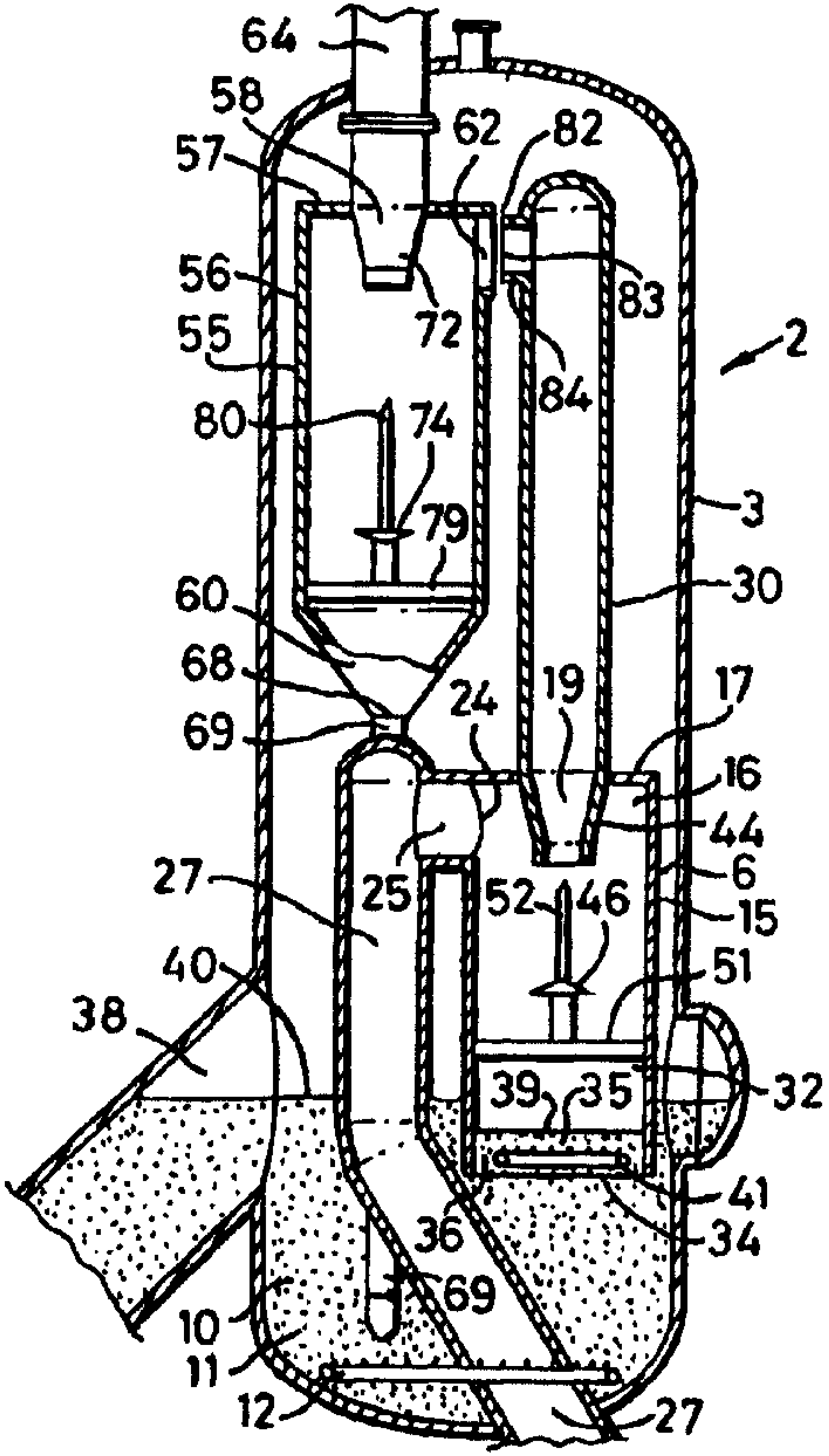


FIG.3



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