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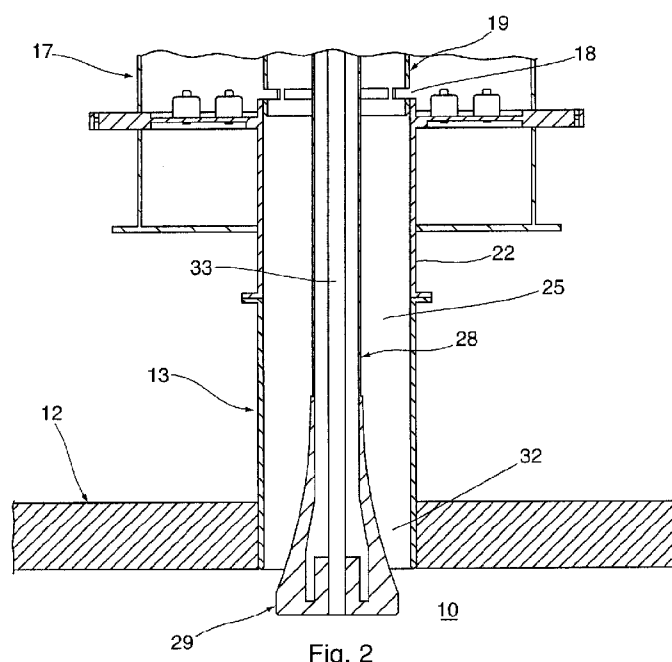


Fig. 2

(57) Abstract: A burner for delivering pulverous feed material and reaction gas to a reaction vessel comprises an outer, elongate tubular member having a peripheral wall. An upper end of the outer tubular member defines a gas supply channel for receiving the reaction gas; a lower end defines a mixing chamber for the reaction gas and the feed material; and an intermediate portion located between the upper and lower ends may have at least one aperture through its outer peripheral wall for receiving the feed material. The burner may comprise an adjustable disperser located inside the outer tubular member and extending from the upper end to the lower end of the outer tubular member. An inner tubular member may be located inside the outer tubular member to define an outer annular passageway, and a valve may be provided for controlling an area of an annular opening of the outer passageway.

## CIRCUMFERENTIAL INJECTION BURNER

CROSS-REFERENCE TO RELATED APPLICATION

- 5   **[0001]**       This application claims priority to and the benefit of United States Provisional Patent Application No. 61/910,214 filed November 29, 2013, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

- 10   **[0002]**       The present subject matter relates to burners for use with pulverous feed materials, such as burners used, for example, for flash smelting sulphide concentrates.

BACKGROUND

- 15   **[0003]**       Flash smelting is a pyrometallurgical process in which a finely ground feed material is combusted with a reaction gas. A flash smelting furnace typically includes an elevated reaction shaft at the top of which is positioned a burner where pulverous feed material (also referred to herein as particulate feed material) and reaction gas are brought together. In the case of copper smelting, the feed material is typically ore concentrates containing both copper and iron sulfide minerals. The concentrates are usually mixed with a silica flux and combusted with pre-heated air  
20   or oxygen-enriched air. Molten droplets are formed in the reaction shaft and fall to the hearth, forming a copper-rich matte and an iron-rich slag layer. Much of the sulfur in the concentrates combines with oxygen to produce sulfur dioxide which can be exhausted from the furnace as a gas and further treated to produce sulfuric acid.

- 25   **[0004]**       A conventional burner for a flash smelter includes an injector having a water-cooled sleeve and an internal central lance, a wind box, and a cooling block that integrates with the roof of the furnace reaction shaft. The lower portion of the injector sleeve and the inner edge of the cooling block create an annular channel. The feed material is introduced from above and descends through the injector sleeve into the reaction shaft. Oxygen enriched combustion air enters the wind box and is

discharged to the reaction shaft through the annular channel. Deflection of the feed material into the reaction gas is promoted by a bell-shaped tip at the lower end of the central lance. In addition, the tip includes multiple perforation jets that direct compressed air outwardly to disperse the feed material in an umbrella-shaped reaction zone. A contoured adjustment ring is mounted around the lower portion of the injector sleeve within the annular channel, and can slide along the vertical axis. The velocity of the reaction gas can be controlled to respond to different flow rates by raising and lowering the adjustment ring with control rods that extend upwardly through the wind box to increase or reduce the cross-sectional flow area in the annular channel. Such a burner for a flash smelting furnace is disclosed in U.S. patent no. 6,238,457.

**[0005]** Known burners of this type are associated with disadvantages that can adversely affect their performance. Conventional methods for introducing feed can result in spatial non-uniformities in the plume, either due to the design of the distributor or due to the accumulation of accretions on the cone-shaped tip and over the perforation air holes.

**[0006]** In known burners, the only method for achieving adequate mixing is to intersect the feed stream with the process gas stream at high velocity within the open space of the reaction shaft. This unconfined collision results in ejection of a portion of the particles from the oxygen-rich portion of the plume into the sulfur dioxide-rich recirculation zone of the reaction shaft.

**[0007]** Existing pre-mixed burners (venturi-type) generally have high smelting performance (low dust production, low reaction shaft heat loads). A problem with the existing pre-mixed burners is that they require high process air velocities to provide mixing with concentrate feed by using the venturi effect. This often prevents the burner from working at lower velocities, which is known to increase residence time within the reaction shaft, leading to higher oxygen efficiency. The fluidized burner allows feed to enter the air stream at a controlled rate, regardless of the process air velocity. In known burners, feed is delivered from a storage bin situated away from the burner via mechanical feeders, mechanical conveyors, or air-assisted conveyors.

These either introduce or transmit periodic or non-periodic fluctuations in the flow rate of feed to the burner, resulting in poor control over the feed to oxygen ratio. Additionally, a common phenomenon is for the feed in the storage bin to become partially fluidized and flow in an uncontrolled manner, greatly disrupting burner  
5 operation.

**[0008]** The above problems, separately or combined, contribute to poor combustion performance of known burners. This is characterized by sub-optimal oxygen efficiency, high dust rates, low dust quality, uptake and burner accretions, local hotspots, high slag metal losses, and matte grade variability. These in turn lead  
10 to displaced production capacity, operational difficulties and onerous maintenance requirements, with the end result of higher operating costs and lower production.

**[0009]** There remains a need for an improved burner that reduces or eliminates many of the above-mentioned problems with the known design.

#### SUMMARY OF THE DISCLOSURE

15 **[00010]** The following summary is intended to introduce the reader to the more detailed description that follows, and not to define or limit the claimed subject matter.

**[00011]** The subject matter described herein relates to a burner design which provides one or more improvements over known burners, including: pre-mixing of the feed and process gas; improved burner plume control; and improved  
20 uniformity of feed flow around the circumference of the burner outlet annulus, both spatially and in time, with minimum particle segregation effects.

**[00012]** According to one aspect, a burner is provided for a pulverous feed material. The burner has a structure that integrates the burner with a reaction vessel, and has an opening that communicates with the interior of the reaction vessel. The  
25 burner also has a mixing chamber to supply a fluidized feed and reaction gas mixture through the opening into the reaction vessel. The burner has a gas supply channel for supplying reaction gas to the mixing chamber. The burner has a means for uniformly introducing feed through a cylindrical opening around the outer periphery of

the gas supply channel. A device that facilitates this method of feed introduction, called a feed flow conditioner, and which addresses the typical feed problems for a flash smelting furnace, as summarized above, is disclosed in commonly assigned U.S. patent application no. 61/835,716, filed on June 17, 2013 and entitled "Feed

5 Flow Conditioner for Particulate Feed Materials".

**[00013]** According to another aspect, a burner is provided for a flash smelting furnace. The burner includes a burner block, a mixing chamber, a gas supply channel, and a feed flow conditioner. The block integrates with the roof of the furnace, and has an opening therethrough to communicate with the reaction shaft of

10 the furnace. A gas supply channel is mounted above the burner block and provides reaction gas to the flash furnace. Inside the gas supply channel are two concentric pipes; a divider pipe and a central lance pipe within, which extends through the entire burner, to supply oxygen to the center of the reaction shaft. A feed flow conditioner is mounted around the gas supply channel. The feed flow conditioner and divider pipe

15 form two concentric annular flow areas around the central lance; an outer annular area, formed by the feed flow conditioner and divider pipe, and an inner annular area, formed by the divider pipe and central lance pipe. Both of these flow areas are fed with reaction gas from the gas supply channel. At the bottom of the feed flow conditioner is located an adjustable aperture, which supplies fluidized feed uniformly

20 around the outer circumference of the outer annular area. A mixing chamber is formed below the aperture, where the fluidized feed from the feed flow conditioner and the reaction gas from the outer annular area of the gas supply channel meet. The mixing chamber allows vigorous mixing of the feed and the reaction gas streams from both the outer annular area and the inner annular area. The mixing chamber is

25 located directly above the opening in the reaction shaft and provides a continuous, circumferentially uniform stream of fluidized feed and reaction gas to the reaction shaft.

**[00014]** Inside the gas supply channel is an iris valve, which is located at the top of the concentric divider pipe. This valve can adjust the portion of flow that is

30 directed through each of the concentric gas flow annuli, formed by the feed flow conditioner, divider pipe and central lance. The valve modifies the proportion of

reaction gas flowing through the outer annular flow area, and the inner annular flow area, thereby modifying the average velocity of the reaction gas entering the reaction shaft. By opening the iris valve, reaction gas is evenly distributed to the two annular flow areas. By closing the iris valve, more of the reaction gas flow is forced through the inner, annular area, thereby increasing the average velocity of the reaction gas exiting the burner. It should be clear to those skilled in the art, that the maximum velocity which can be achieved through the burner controlled by the iris valve is governed by the size of the inner annular area. The highest outlet velocity is achieved when the iris valve is in the fully closed position and all gas is forced through the inner annulus.

**[00015]** In some examples, a nesting insert sleeve with helical swirl generating vanes can be inserted around the central lance to add a tangential flow component to reaction gas through the inner annulus and induce swirling within the reaction shaft. This can be used to expand the plume, thereby eliminating the need for a physical bluff body.

**[00016]** In some examples, the inserts can be externally controlled components that can be moved vertically to control the swirling or turbulence of the reaction gas.

**[00017]** In some examples, the pitch and width of the vanes of the swirler insert can be adjusted to achieve different maximum swirl number (swirl intensity).

**[00018]** In some examples, the central lance pipe can be fitted with a cone at its lower end, to force the reaction gas exiting the inner annulus radially outwards.

**[00019]** In some examples, the central lance pipe with cone tip can be moved vertically to control the inner, annular gap opening size to control the velocity of the reaction gas leaving the inner annulus.

**[00020]** In some examples, the central lance pipe can be fitted with an inverted cone at the upper end, to control the area of the inner annular gap. By closing the annular gap, more of the reaction gas flow is forced through the outer annular area,

thereby increasing the average velocity of the reaction gas exiting the burner. It should be clear to those skilled in the art, that the maximum velocity which can be achieved through the burner controlled by the inverted cone is governed by the size of the outer annular area. The highest outlet velocity is achieved when the inverted  
5 cone is in the fully closed position and all gas is forced through the outer annulus.

**[00021]** In some examples, the iris valve, divider pipe and central lance can be replaced with an inner lance, where the annular gap opening size between the mixing chamber and the inner lance controls the velocity of the fluidized feed and reaction gas mixture.

10 **[00022]** In some examples, the inner lance can be moved vertically to control the annular gap opening size, which effectively controls the exit velocity of the reaction gas and fluidized feed mixture.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[00023]** In order that the claimed subject matter may be more fully understood,  
15 reference will be made to the accompanying drawings, in which:

**[00024]** Fig. 1 is a cross-sectional view of a burner for a flash smelting furnace according to a first embodiment containing an adjustable disperser to control the average gas flow velocity into the reaction shaft.

**[00025]** Fig. 2 is a detailed view of the burner of Figure 1.

20 **[00026]** Fig. 3 is a cross-sectional view of a burner for a flash smelting furnace according to a second embodiment, where the disperser is replaced with two concentric annuli and an iris valve to control the average gas flow velocity into the reaction shaft.

**[00027]** Fig. 4 is a detailed view of the burner of Figure 3.

**[00028]** Fig. 5 is a cross-sectional view of a burner for a flash smelting furnace according to a third embodiment containing a cone at the lower end of the central lance to control the angle of gas exiting the inner annulus.

**[00029]** Fig. 6 is a detailed view of the burner of Figure 5.

5 **[00030]** Fig. 7 is a cross-sectional view of a burner for a flash smelting furnace according to a fourth embodiment containing an inverted cone at the top end of the central lance to control the average gas flow velocity into the reaction shaft.

**[00031]** Fig. 8 is a detailed view of the burner of Figure 7.

#### DETAILED DESCRIPTION OF EMBODIMENTS

10 **[00032]** In the following description, specific details are set out to provide examples of the claimed subject matter. However, the embodiments described below are not intended to define or limit the claimed subject matter. It will be apparent to those skilled in the art that many variations of the specific embodiments may be possible within the scope of the claimed subject matter.

15 **[00033]** As shown in Figures 1 and 2, a burner 11 is positioned above the reaction shaft 10 of a flash smelting furnace. The base of the burner 11 comprises a cooled block 12 which integrates into the roof of the reaction shaft 10 of the furnace and a nozzle 13 which extends through the cooled block 12. A gas supply channel 14 is mounted above the nozzle 13, and is supplied with reaction gas. Inside the gas  
20 supply channel 14 is an adjustable disperser 28, which protrudes down into the burner 11. The adjustable disperser 28 extends through the burner 11 and the nozzle 13, into the reaction shaft 10. The adjustable disperser 28 may contain an integrated fuel burner or an oxygen passage through the center (details not shown), as well as a water-cooled element on its bottom surface.

25 **[00034]** Located around the gas supply channel 14 is a feed flow conditioner 17, such as the feed flow conditioner described in above-mentioned U.S. provisional patent application no. 61/835,716, which is incorporated herein by reference in its

entirety. The description of the feed flow conditioner will not be repeated here. The feed flow conditioner contains a fluidized bed of solid particulate feed material in a fluidizing gas. The feed flow conditioner 17 contains a cylindrical sliding sleeve 19, which can be moved vertically (longitudinally) to control the height and area of an adjustable aperture 18, through which the feed flow conditioner 17 provides a uniform flow of solid particulate feed material, entrained in the fluidizing gas, around the entire circumference of the burner 11 through a lower annular channel 31 defined between the sliding sleeve 19 and the adjustable disperser 28. By adjusting the position of the cylindrical sliding sleeve 19, the adjustable aperture 18 can be increased in height to allow more particulate feed material into the burner 11, or decreased in height to reduce the flow.

**[00035]** The burner 11 is mounted on the furnace support structure and the nozzle 13 extends through the burner block 12 which provides the main seal between the reaction shaft of the furnace and the burner 11. The inner surface of the gas supply channel 14 and the outer surface of the adjustable disperser 28 define an upper annular channel 30. The inner surface of the cylindrical sliding sleeve 19 and the outer surface of the adjustable disperser 28 define the lower annular channel 31. Reaction gas from the gas supply channel 14 enters both annular channels 30 and 31.

**[00036]** At the upper end of cylindrical sliding sleeve 19 an annular gap 8 or other opening may be provided to permit fluidizing gas from upper portion of the feed flow conditioner 17 to enter the lower annular channel 31. The area of this gap 8 can be adjusted by raising or lowering the cylindrical sliding sleeve 19.

**[00037]** The feed flow conditioner 17 controls the flow of fluidized particulate feed material into the lower annular channel 31. The fluidized feed material is uniformly distributed through the adjustable aperture 18 around the outer circumference of the lower annular channel 31. The feed material and reaction gas in the lower annular channel 31 flow downwardly into a mixing chamber 25 just above the reaction shaft 10, the mixing chamber 25 comprising an annular space between the inner surfaces of the feed flow conditioner discharge pipe 22 and the nozzle 13,

and the outer surface of the adjustable disperser 28. The mixing chamber 25 allows the fluidized feed material and reaction gas to vigorously mix prior to entering the reaction shaft.

5       **[00038]**       The adjustable disperser 28 extends down into the upper portion of the reaction shaft 10 of the furnace. The adjustable disperser 28 has a tip 29 at its lower end, which extends below the nozzle 13 and block 12. The disperser tip 29 has a frustoconical shape and directs the feed and reaction gas mixture outwardly. The adjustable disperser 28 may contain openings (not shown) through which compressed air is injected horizontally to assist in directing the feed and reaction gas  
10       mixture in an umbrella pattern through the reaction shaft 10 of the furnace.

15       **[00039]**       The adjustable disperser 28 can be moved vertically to adjust the size of the annular nozzle opening 32. By lowering the adjustable disperser 28, the cross-sectional area of the annular nozzle opening 32 is increased, thereby decreasing the average velocity of the feed and gas mixture exiting the burner. By raising the  
20       adjustable disperser 28, the cross-sectional area of the annular nozzle opening 32 is decreased, thereby increasing the average velocity of the feed and gas mixture exiting the burner 11. It should be clear to those skilled in the art, that the maximum velocity which can be achieved through the burner controlled by the adjustable disperser 28 is governed by the size of the annular area formed between the nozzle  
25       13 and the disperser tip 29. The highest outlet velocity is achieved when the disperser tip 29 is inserted completely into the nozzle 13.

**[00040]**       The vertical position of the adjustable disperser 28 is controlled by a positioning motor 27 mounted externally to the burner 11. The positioning motor 27 is governed by a PLC (programmable logic control).

25       **[00041]**       This method of injecting a feed and reaction gas mixture evenly around the annular nozzle opening 32 avoids the conventional approach of colliding separate feed and air streams at opposing angles, which is known to increase dust carry-over by ejecting particles from the combustion plume.

**[00042]** A second embodiment is shown in Figures 3 and 4. Similar components are given like names and like reference numbers, and their description will not be repeated.

**[00043]** Inside the gas supply channel 13 are a divider pipe 15 and a central lance 16, both of which protrude down into the burner nozzle 13. These components replace the disperser 28 shown in the first embodiment. The central lance 16 extends through the nozzle 13 into reaction shaft 10, while the divider pipe 15 terminates inside the nozzle 13. The central lance 16 is used to inject oxygen into the plume, but may also be used for a fuel burner.

**[00044]** In the upper portion of the burner 11, the inner surface of the gas supply channel 14 and the outer surface of the divider pipe 15 define an upper outer annular channel 20. Lower inside the burner 11, the inner surfaces of the cylindrical sliding sleeve 19 and feed flow conditioner discharge pipe 22 and the outer surface of the divider pipe 15 define a lower outer annular channel 21. Similarly, the inner surface of the divider pipe 15 and the outer surface of the central lance 16 define an inner annular channel 23. Reaction gas from the gas supply channel 14 enters both the outer annular channels 20, 21 and/or the inner annular channel 23, as further discussed below.

**[00045]** Above the feed flow conditioner 17 is an iris valve 24, which is used to control the size of an annular opening 34 into the upper outer annular channel 20, as shown in Figure 4. When the iris valve 24 is fully open, reaction gas flow is allowed to enter the outer annular channels 20, 21 and the inner annular channel 23. The iris valve 24 can modulate the size of the opening 34 of the upper annular channel 20, with the fully closed position not allowing any reaction gas to flow into the outer annular channels 20, 21. This effectively forces all reaction gas to flow through the inner annular channel 23. It should be clear to those skilled in the art, that the maximum velocity which can be achieved through the burner is governed by the cross-sectional area of the inner annular channel 23. The highest outlet velocity is achieved when the iris valve 24 and the opening 34 are fully closed.

**[00046]** The feed flow conditioner 17 controls the flow of fluidized particulate feed into the lower outer annular channel 21. The fluidized feed is uniformly distributed through the adjustable aperture 18 around the outer circumference of the lower outer annular channel 21 allowing mixing of the feed material and reaction gas.

5 The feed material and reaction gas in the lower outer annular channel 21 flow into the nozzle 13, which defines a mixing chamber 25 just above the reaction shaft. The mixing chamber allows the fluidized feed and reaction gas from the lower outer annular area 21 to vigorously mix with the reaction gas from the inner annular channel 23. This allows pre-mixing of the fluidized feed and reaction gas prior to  
10 entering the reaction shaft 10.

**[00047]** Inside the divider pipe 15 of burner 11 is a swirler insert sleeve 26, which is positioned concentrically around the central lance 16, inside the inner annular channel 23. The swirler insert sleeve 26, as shown in Fig. 4, comprises a plurality of vanes, which impart a tangential velocity to the passing reaction gas,  
15 thereby inducing an overall swirling motion of the fluid flowing through the inner annular channel 23 into the mixing chamber 25, and eventually into the reaction shaft of the furnace. The total tangential (swirling) velocity of the reaction gas jet emerging from the nozzle 13 of the burner can be manipulated by varying the vertical position of the swirler insert sleeve 26. When the swirler insert sleeve 26 is in the lower  
20 position, toward the lower end of divider pipe 15, the swirling motion of the reaction gas exiting the inner annular channel 23 and nozzle 13 is maximized. When the swirler insert sleeve 26 is progressively raised along the central lance 16, toward the upper end of divider pipe 15, the swirling motion of the reaction gas that exits the inner annular channel 23 decreases, as the swirling effects diminish proportionally  
25 with the distance of the swirler insert sleeve 26 to the exit of the divider pipe 15. Manipulation of the swirl of the reaction gas allows control over the overall burner plume shape as well as the mixing characteristics within the reaction shaft.

**[00048]** The vertical position of the swirler insert sleeve 26 is controlled by a positioning motor 27 mounted externally to the burner. The positioning motor 27 is  
30 governed by a PLC (programmable logic control). Adjusting the vertical position of the swirler insert sleeve 26, for example by operating motor 27 to raise or lower the

central lance 16 and/or the swirler insert sleeve 26, can manipulate the shape of the jet plume exiting the burner. Increasing the total tangential (swirling) velocity of the fluidized feed and reaction gas mixture exiting the burner allows for a larger plume, and will tend to move the finer particles towards to the outside of the plume, increasing the heat absorbed from the surrounding recirculation gases within the furnace, facilitating heat transfer and promoting earlier ignition. Minimizing the swirling velocity of the mixture exiting the burner, allows for a smaller more focused plume jet, which can minimize the dust rate, temperature and wear of the reaction shaft refractory lining.

- 10 **[00049]** The vertical position of the swirler insert sleeve 26 controls the degree of swirling independently of the axial velocity of the reaction gas, which is controlled by iris valve 24, which modulates the proportion of reaction air flowing through the outer annular channels 20, 21 and the inner annular channel 23.

- 15 **[00050]** A third embodiment is shown in Figures 5 and 6. Similar components are given like names and like reference numbers, and their description will not be repeated.

- 20 **[00051]** This embodiment is similar to that shown in Figures 3 and 4, except that both the divider pipe 15 and central lance 16 extend to the lower end of the nozzle 13. The central lance 16 includes a lance cone 35 at its lower end to control the cross-sectional area of the exit opening 36 of the inner annular channel 23, as shown in Figure 6. The central lance 16 can be fixed inside the burner 11, while the lance cone 35, which is concentric to the central lance 16, can be moved vertically, or the central lance 16 can be moved together with the lance cone 35, to adjust the plume shape.

- 25 **[00052]** The lance cone 35 and/or the lance 16 can be raised and lowered by the positioning motor 27 mounted externally to the burner. The positioning motor 27 is governed by a PLC (programmable logic control).

**[00053]** The vertical position and geometry of the lance cone 35 can be modulated to adjust the exit velocity magnitude and direction of the reaction gas at the exit opening 36 of the inner annular channel 23, which would modify the plume shape. When the lance cone 35 is raised, the exit opening 36 of the inner annular channel 23 is reduced. Furthermore, the reaction gas jet leaving the inner annular channel 23 is forced to closely follow the geometry of the lance cone and exit with a velocity radial component. The reaction gas jet exiting the inner annular channel 23 will join the feed and reaction gas mixture exiting the mixing chamber 25, effectively expanding the shape of the plume in the reaction shaft. As the lance cone 35 is lowered, the exit opening 36 of the inner annular channel 23 is increased, reducing the exiting velocity magnitude and minimizing the radial and axial components of the flow, thereby reducing the diameter and length of the plume.

**[00054]** The iris valve 24 is used to control the flow rate ratio of the process gas through the outer annular channels 20, 21 and the inner annular channel 23. Independent control of the process gas through channels 20 and 23 also can be arranged. This allows independent control of the mass flow and the velocity of the reaction gas jet exiting the inner annular channel 23, and the reaction gas entrained in the feed material, coming out of the feed flow conditioner 17, in the outer annular channel 25.

**[00055]** This embodiment effectively controls the size of the recirculation bubble that forms under the lance cone 35, and allows greater control of the shape of the plume in the reaction shaft. Modification of the geometry of lance cone 35, like adding a downwardly extending cone at the bottom of cone 35, can minimize the recirculation bubble.

**[00056]** It will be appreciated by those skilled in the art that the divider pipe can be reduced in length such that it terminates inside the nozzle, allowing a larger mixing chamber for the fluidized feed and reaction gas, prior to entering the reaction shaft.

**[00057]** It will be appreciated by those skilled in the art that a swirl insert similar to that shown in figure 4 can be used in conjunction with the lance cone to control swirl and the radial velocity component of the plume.

**[00058]** A fourth embodiment is shown in Figures 7 and 8. Similar components are given like names and like reference numbers, and their description will not be repeated.

**[00059]** Inside the gas supply channel 13 are a divider pipe 15 and a central lance 16, which protrude down into the burner nozzle 13. The central lance 16 extends through the nozzle 13, while the divider plate 15 terminates inside the nozzle 13. The central lance 16 is used to inject oxygen into the plume, but may also contain a fuel burner.

**[00060]** The central lance contains an inverted lance cone 37 located near the top end of the divider pipe 15, to control the size of an annular opening 38 into the inner annular channel 23, as shown in Figure 8. The central lance 16 remains fixed inside the burner 11, while the inverted lance cone 37, which is concentric to the central lance 16, can be moved vertically to adjust the opening size of the inner annular channel 23.

**[00061]** The inverted lance cone 37 can be raised and lowered by the positioning motor 27 mounted externally to the burner for example by operating motor 27 to raise or lower the central lance 16 and/or the inverted lance cone 37. The positioning motor 27 is governed by a PLC (programmable logic control).

**[00062]** The vertical position of the inverted lance cone 37 can be modulated to adjust the proportion of reaction gas flow entering the outer annular channels 20, 21 and the inner annular channel 23. When the inverted lance cone 37 is raised, the opening 38 of the inner annular channel 23 is increased, allowing more reaction gas to flow into the inner annular channel 23. As the inverted lance cone 37 is lowered, the opening 38 of the inner annular channel 23 is decreased, reducing the amount of reaction gas flowing into the inner annular channel 23. The reaction gas jet exiting

the inner annular channel 23 will join the feed and reaction gas mixture exiting the lower outer annular channel 21 in the mixing chamber 25.

5     **[00063]**     This embodiment allows better control of the plume velocity and maintains a higher velocity in the outer annular channels 20, 21 than in the inner annular channel 23. This allows better control of the mixing as the fluidized feed first mixes with the reaction gas in the lower annular channel 23.

**[00064]**     It will be appreciated by those skilled in the art that many variations are possible within the scope of the claimed subject matter. The embodiments that have been described above are intended to be illustrative and not defining or limiting.

10   **[00065]**     For example, the vertically moving velocity and plume controlling components (i.e. adjustable disperser, swirler insert sleeve, lance cone and inverted lance cone) can be controlled with an actuator, which may be hydraulic, pneumatic or a mechanical screw jack.

15   **[00066]**     The burner described herein may also be designed with reaction air injected into an annulus that is outside the feed containing annulus, effectively creating an air shroud which may reduce the build-up of accretions on the nozzle, and further reducing the tendency to create particle carry-over

20   **[00067]**     The disperser cone and lance cone described herein may have a different geometry to modify the bluff body effects and recirculation zones to better control the plume shape within the reaction shaft.

**[00068]**     While the above subject matter has been described in the context of burners for flash smelting furnaces, it will be appreciated that it may also have application to other burner for pulverous feed materials, such as burners for furnaces that are fueled by pulverous coal.

25

What is claimed is:

1. A burner for delivery of a mixture of pulverous feed material and reaction gas to a reaction vessel, the burner comprising an outer, elongate tubular member having  
5 an outer peripheral wall, the outer tubular member comprising:

an upper end defining a gas supply channel for receiving the reaction gas;

- 10 a lower end defining a mixing chamber in which the reaction gas and the pulverous feed material are mixed together; and

an intermediate portion between the upper and lower ends, the intermediate portion having at least one aperture through the outer peripheral wall for receiving the pulverous feed material.

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2. The burner of claim 1, wherein the outer peripheral wall of the outer tubular member has a circumference, and wherein the at least one aperture extends around substantially the entire circumference of the outer peripheral wall.

- 20 3. The burner of claim 1 or 2, wherein the intermediate portion of the outer tubular member is located inside a feed flow conditioner containing the particulate feed material.

- 25 4. The burner of claim 3, wherein the particulate feed material in the feed flow conditioner is fluidized by a fluidizing gas.

5. The burner of claim 3 or 4, wherein the intermediate portion of the outer tubular member is at least partly defined by a cylindrical sliding sleeve, and wherein the at least one aperture has an area which is controllable by adjusting a position of  
30 the cylindrical sliding sleeve.

6. The burner of any one of claims 1 to 5, further comprising an adjustable disperser located inside the outer tubular member, the disperser extending from the upper end to the lower end of the outer tubular member.
- 5 7. The burner of claim 6, wherein the adjustable disperser is substantially concentric with the outer peripheral wall of the outer tubular member, such that the mixing chamber comprises an annular space between the disperser and the outer peripheral wall of the outer tubular member.
- 10 8. The burner of claim 6 or 7, wherein the adjustable disperser has an enlarged tip at its lower end, and wherein an annular opening into the reaction vessel is defined between the enlarged tip and the outer peripheral wall of the outer tubular member.
- 15 9. The burner of claim 8, wherein the enlarged tip has a frustoconical shape, such that an area of the annular opening is adjustable by raising or lowering the adjustable disperser within the outer tubular member of the burner.
- 20 10. The burner of any one of claims 1 to 9, wherein the lower end of the tubular member is defined by a nozzle of the reaction vessel.
- 25 11. The burner of any one of claims 1 to 5, further comprising an inner tubular member located inside the outer tubular member and concentric therewith, wherein an outer annular passageway is defined between the inner and outer tubular members.
- 30 12. The burner of claim 11, wherein the inner tubular member has an upper end spaced below the upper end of the outer tubular member, at which an annular inlet opening is provided, and wherein the burner further comprises a valve for controlling an area of the annular opening.
13. The burner of claim 12, wherein the valve is an iris valve.

14. The burner of any one of claims 11 to 13, wherein the inner tubular member has a lower end spaced above the lower end of the outer tubular member, such that the mixing chamber is defined as a vertical space between the lower end of the inner  
5 tubular member and the lower end of the outer tubular member.

15. The burner of any one of claims 11 to 14, further comprising an adjustable lance located inside the inner tubular member, the lance extending through the upper and lower ends of the inner tubular member.

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16. The burner of claim 15, wherein the lance is substantially concentric with the inner tubular member, such that an inner annular passageway is defined between the lance and the inner tubular member.

15 17. The burner of claim 15 or 16, wherein the lance is provided with a swirl generator, and wherein the swirl generator is movable vertically along the lance.

18. The burner of claim 17, wherein the swirl generator is vertically movable between the upper end and the lower end of the inner tubular member.

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19. The burner of claim 15 or 16, wherein:  
the lower end of the inner tubular member is proximate to the lower end of the outer tubular member;

the adjustable lance has an enlarged tip at its lower end; and  
25 wherein an annular opening into the reaction vessel is defined between the enlarged tip and the outer peripheral wall of the inner tubular member.

20. The burner of claim 19, wherein the enlarged tip has a frustoconical shape, such that an area of the annular opening is adjustable by raising or lowering the  
30 adjustable lance within the inner tubular member of the burner.

21. The burner of any one of claims 1 to 5, further comprising an inner tubular member located inside the outer tubular member and concentric therewith, and an adjustable lance located inside the inner tubular member, the lance extending through the upper and lower ends of the inner tubular member, wherein:

5 an outer annular passageway is defined between the inner and outer tubular members;

the inner tubular member has an upper end spaced below the upper end of the outer tubular member, at which an annular inlet opening is provided; and

10 the lance is provided with an enlarged portion proximate to the upper end of the inner tubular member.

22. The burner of claim 21, wherein the enlarged portion is vertically movable relative to the upper end of the inner tubular member such that an area of the annular inlet opening is adjustable by raising or lowering the enlarged portion.

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23. The burner of claim 22, wherein the enlarged portion has a frustoconical shape and is at least partly located below the upper end of the inner tubular member.

24. The burner of claim 23, wherein the enlarged portion has a maximum diameter  
20 which is at least as large as an outside diameter of the annular inlet opening.

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Fig. 1

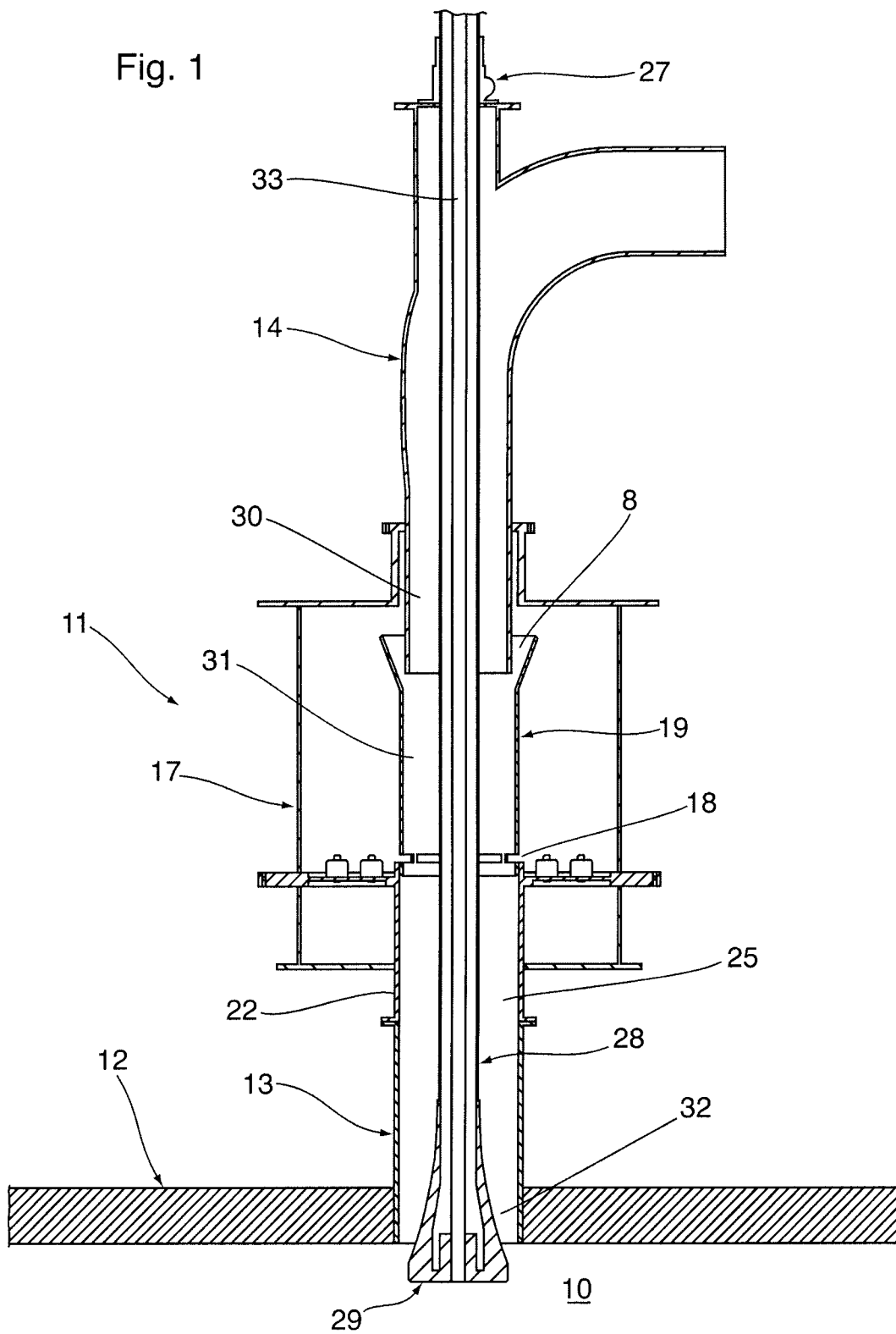
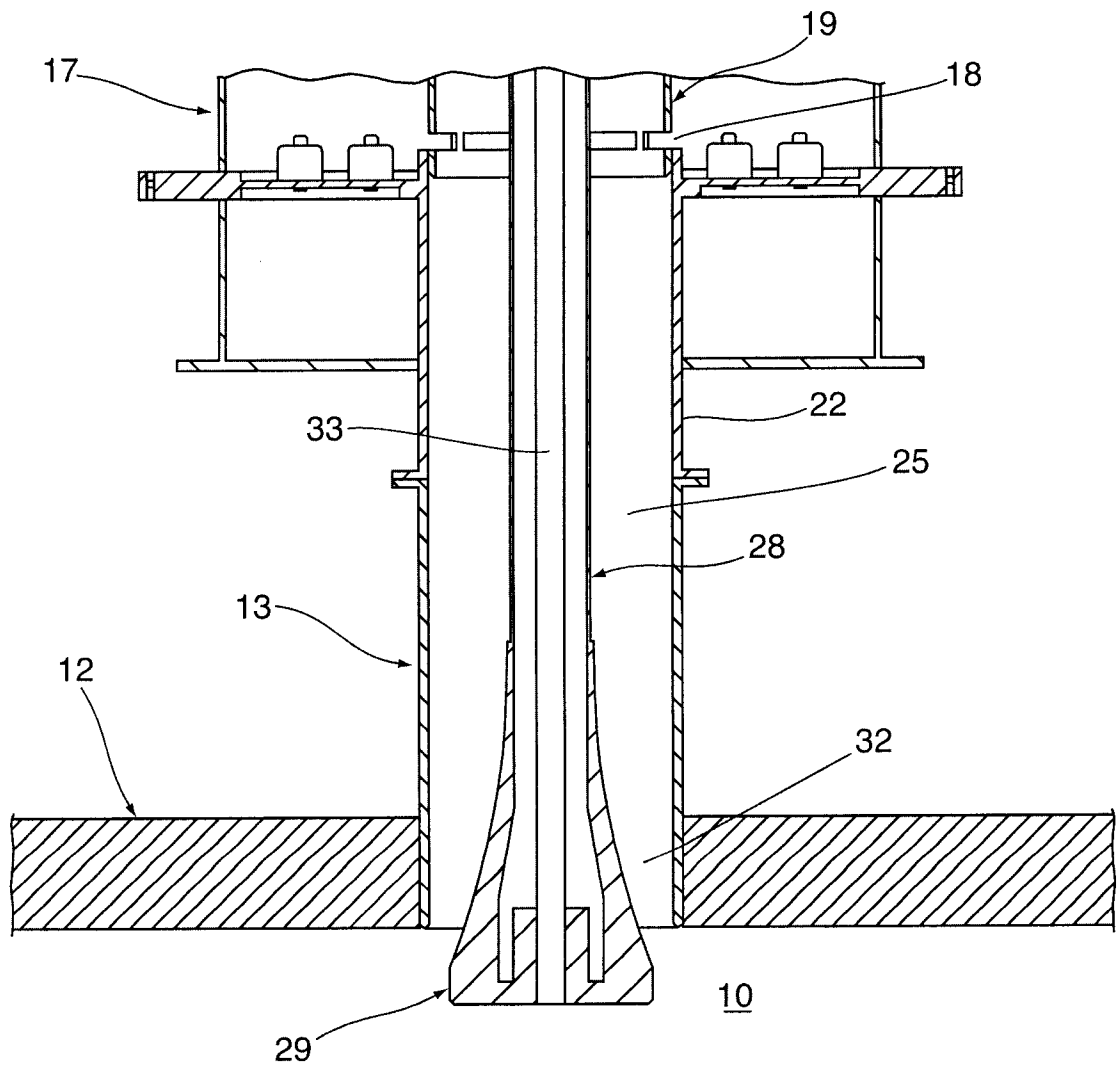


Fig. 2



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Fig. 3

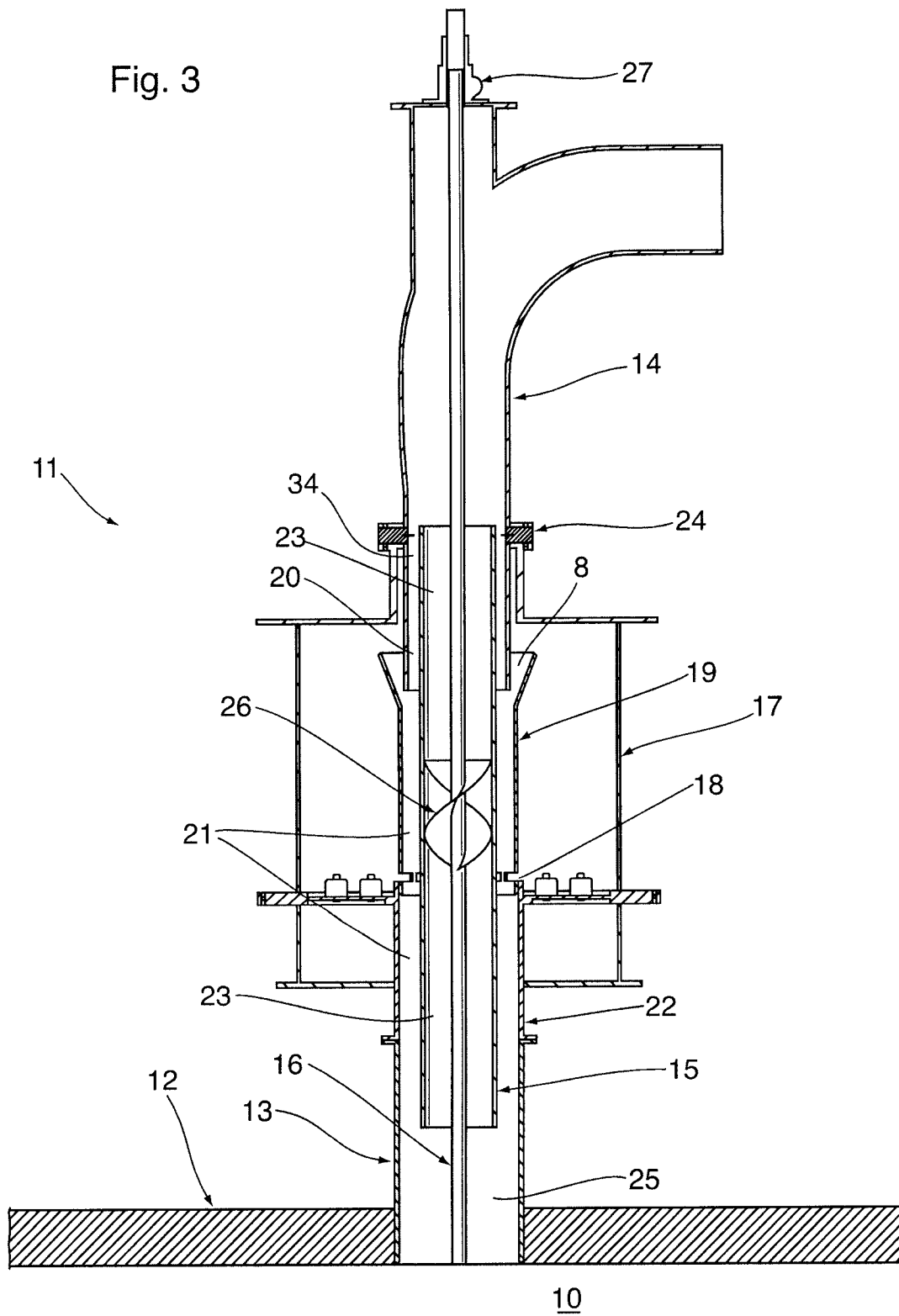
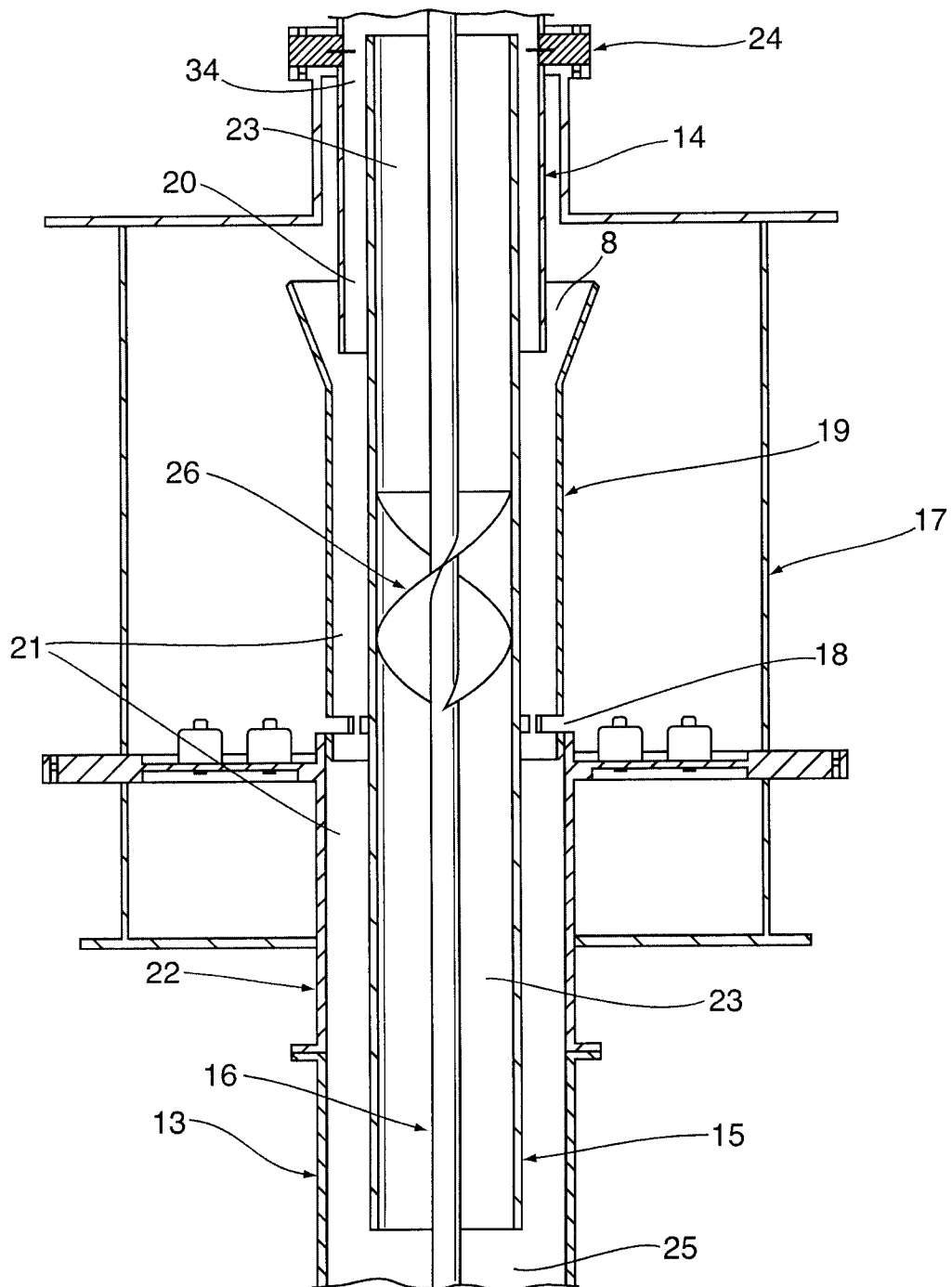


Fig. 4



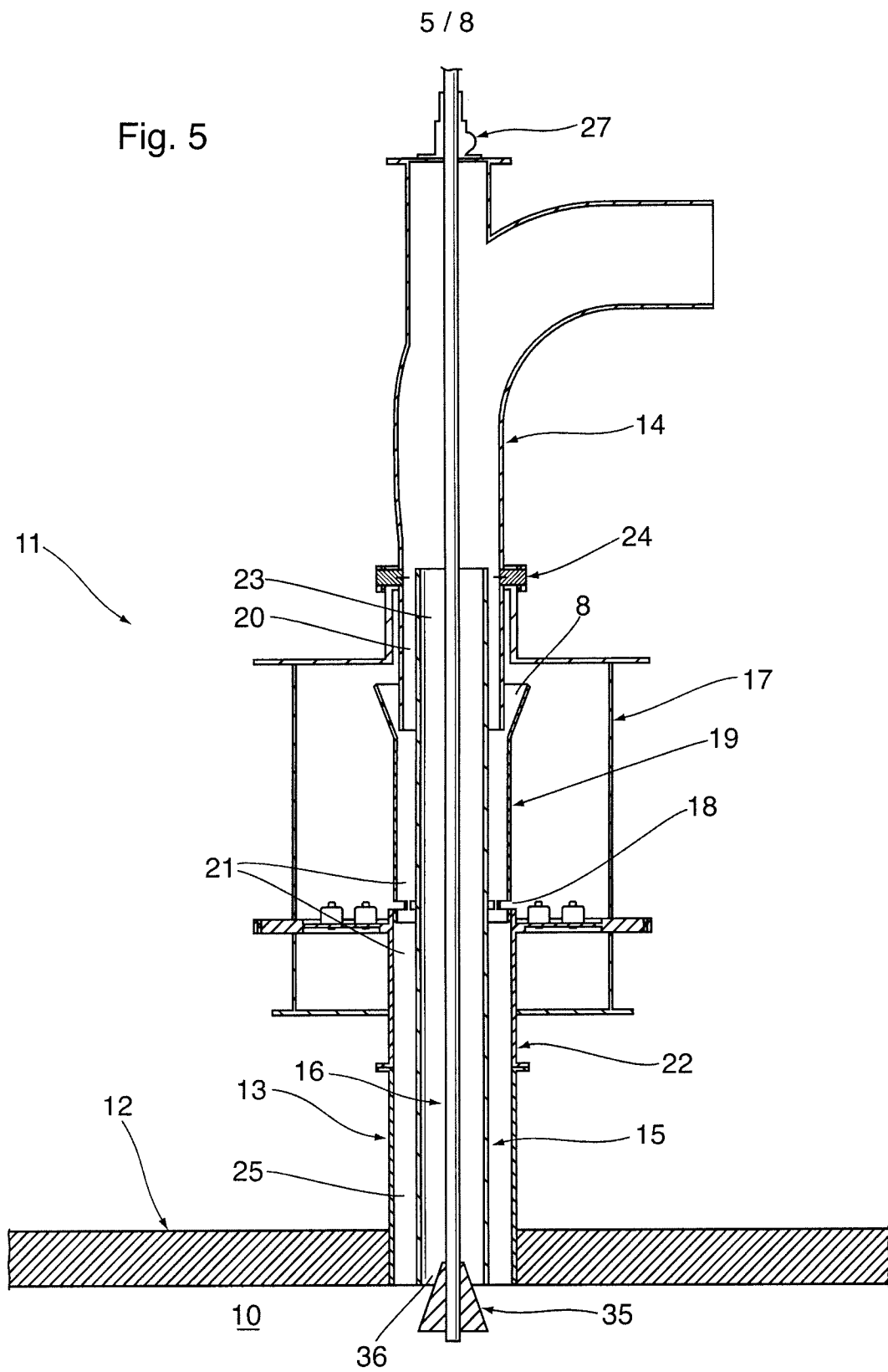
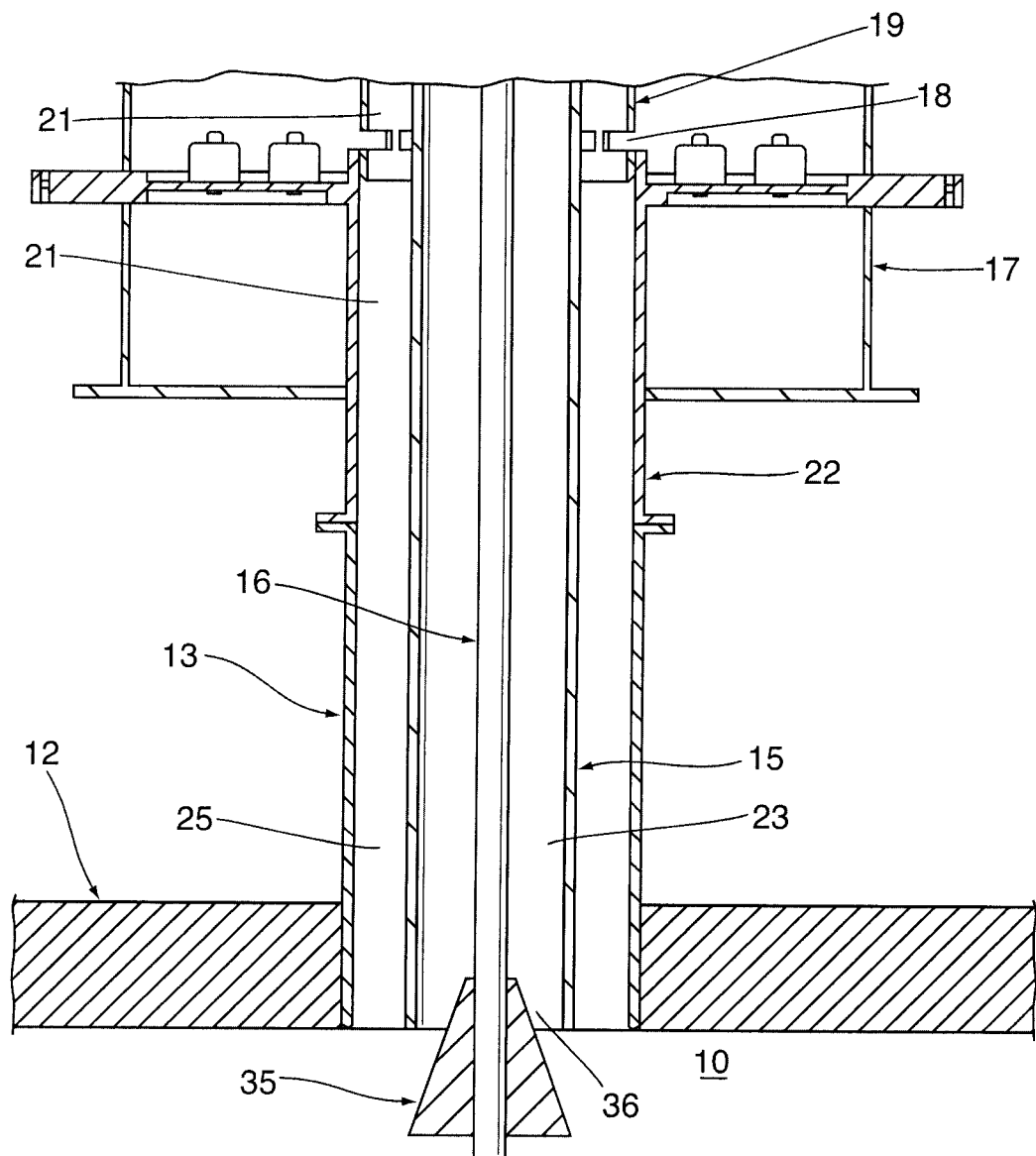


Fig. 6



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Fig. 7

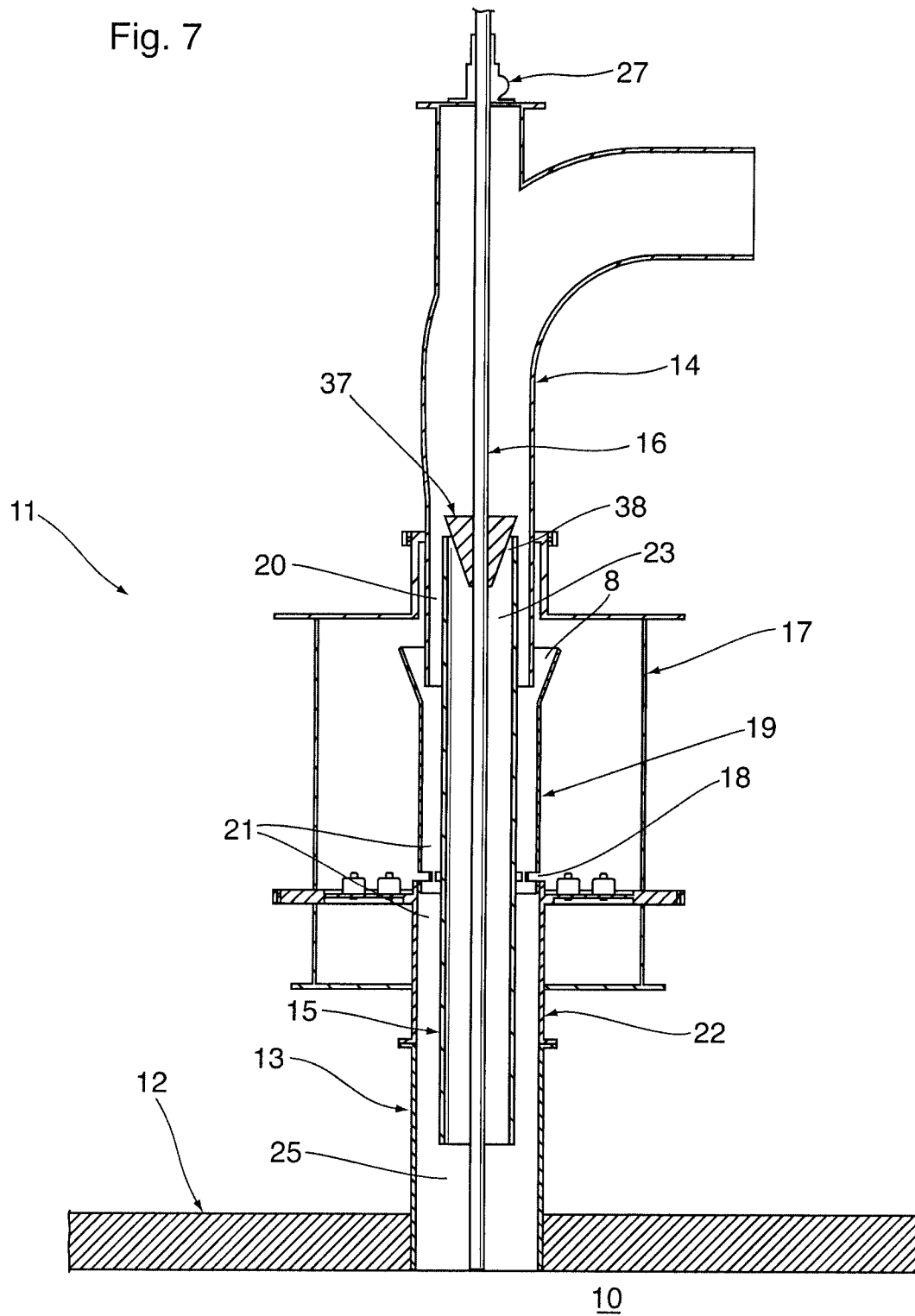
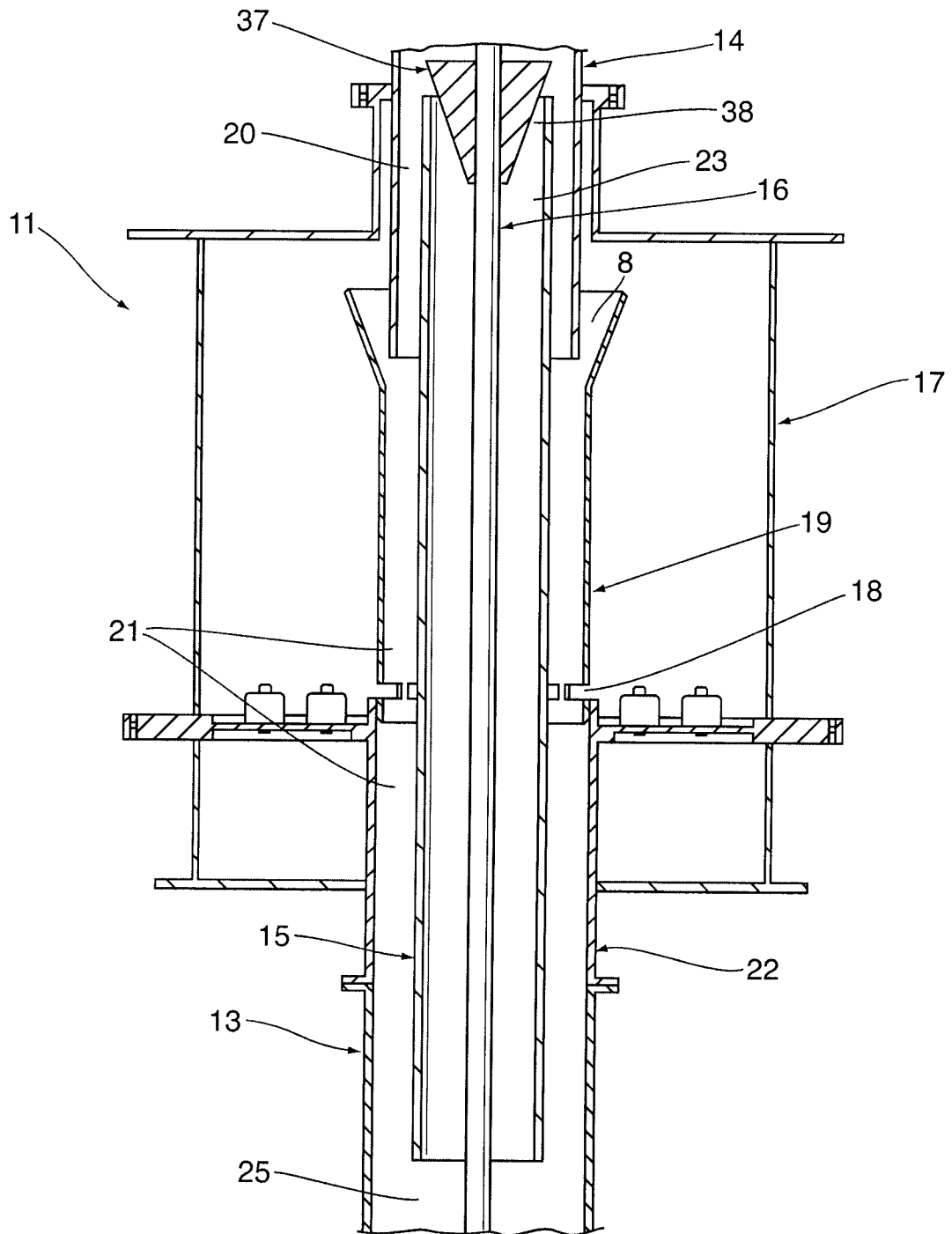


Fig. 8



## INTERNATIONAL SEARCH REPORT

International application No.

**PCT/CA2014/051102**

## A. CLASSIFICATION OF SUBJECT MATTER

IPC: **F23D 1/04** (2006.01), **B01J 6/00** (2006.01), **B01J 8/00** (2006.01), **C22B 9/05** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (2006.01): F23D 1/04, B01J 6/00, B01J 8/00, C22B 9/05 USPC : 422/145

ECLA : F23K 3/00; F27B 15/00; F27B 15/02; F23D 1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

Questel Orbit

Search Terms: feed flow conditioner, fluidized, smelting

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                    | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------------|-----------------------|
| X, E      | WO2014/201556A1 (KOKOURINE, A., et al.) 24 December 2014 (24-12-2014)<br>*Cited by Applicant*<br>*The whole document* | 1-5                   |
| A         | US6843185B1 (TAYLOR, C.) 18 January 2005 (18-01-2005)<br>*Figure 2*                                                   | 1                     |
| A         | US6238457B1 (HOLMI, I., et al.) 29 May 2001 (29-05-2001)<br>*Cited by Applicant*<br>*Figure 2*                        | 1                     |

|                          |                                                            |                                     |                          |
|--------------------------|------------------------------------------------------------|-------------------------------------|--------------------------|
| <input type="checkbox"/> | Further documents are listed in the continuation of Box C. | <input checked="" type="checkbox"/> | See patent family annex. |
|--------------------------|------------------------------------------------------------|-------------------------------------|--------------------------|

|                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *<br>"A"<br>"E"<br>"L"<br>"O"<br>"P" | Special categories of cited documents:<br>document defining the general state of the art which is not considered to be of particular relevance<br>earlier application or patent but published on or after the international filing date<br>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)<br>document referring to an oral disclosure, use, exhibition or other means<br>document published prior to the international filing date but later than the priority date claimed | "T"<br>"X"<br>"Y"<br>"&" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention<br>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone<br>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art<br>document member of the same patent family |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Date of the actual completion of the international search  
15 January 2015 (15-01-2015)Date of mailing of the international search report  
02 February 2015 (02-02-2015)Name and mailing address of the ISA/CA  
Canadian Intellectual Property Office  
Place du Portage I, C114 - 1st Floor, Box PCT  
50 Victoria Street  
Gatineau, Quebec K1A 0C9  
Facsimile No.: 001-819-953-2476

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

**PCT/CA2014/051102**

| Patent Document<br>Cited in Search Report | Publication<br>Date           | Patent Family<br>Member(s)                                                                                                                                                                                                                                                                                                                                                                                                             | Publication<br>Date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WO2014201556A1                            | 24 December 2014 (24-12-2014) | None                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| US6843185B1                               | 18 January 2005 (18-01-2005)  | US2004261671A1<br>WO2005005885A2<br>WO2005005885A3                                                                                                                                                                                                                                                                                                                                                                                     | 30 December 2004 (30-12-2004)<br>20 January 2005 (20-01-2005)<br>24 March 2005 (24-03-2005)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| US6238457B1                               | 29 May 2001 (29-05-2001)      | US6238457B1<br>AR009955A1<br>AU730365B2<br>AU4461797A<br>BR9712175A<br>CA2267296A1<br>CA2267296C<br>CN1232538A<br>CN1113213C<br>DE19782044B3<br>DE19782044T1<br>ES2168932A1<br>ES2168932B2<br>FI100889B<br>ID21552A<br>JP2001501294A<br>JP4309476B2<br>KR20000048734A<br>KR100509405B1<br>PE104098A1<br>PL332671A1<br>PL183755B1<br>RU2198364C2<br>SE9901200D0<br>SE9901200L<br>SE517103C2<br>TR9900761T2<br>WO9814741A1<br>ZA9708694A | 29 May 2001 (29-05-2001)<br>17 May 2000 (17-05-2000)<br>08 March 2001 (08-03-2001)<br>24 April 1998 (24-04-1998)<br>31 August 1999 (31-08-1999)<br>09 April 1998 (09-04-1998)<br>20 September 2005 (20-09-2005)<br>20 October 1999 (20-10-1999)<br>02 July 2003 (02-07-2003)<br>02 February 2012 (02-02-2012)<br>26 April 2001 (26-04-2001)<br>16 June 2002 (16-06-2002)<br>16 September 2003 (16-09-2003)<br>13 March 1998 (13-03-1998)<br>24 June 1999 (24-06-1999)<br>30 January 2001 (30-01-2001)<br>05 August 2009 (05-08-2009)<br>25 July 2000 (25-07-2000)<br>22 August 2005 (22-08-2005)<br>04 February 1999 (04-02-1999)<br>27 September 1999 (27-09-1999)<br>31 July 2002 (31-07-2002)<br>10 February 2003 (10-02-2003)<br>01 April 1999 (01-04-1999)<br>31 May 1999 (31-05-1999)<br>16 April 2002 (16-04-2002)<br>21 June 1999 (21-06-1999)<br>09 April 1998 (09-04-1998)<br>26 March 1998 (26-03-1998) |