



- (51) International Patent Classification:
C22B 9/10 (2006.01)
- (21) International Application Number:
PCT/US2012/035845
- (22) International Filing Date:
30 April 2012 (30.04.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/480,982 29 April 2011 (29.04.2011) US
- (71) Applicant (for all designated States except US): **BERRY METAL COMPANY** [US/US]; 2408 Evans City Road, Harmony, PA 16037 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **WHITE, Jacob, J.** [US/US]; 2408 Evans City Road, Harmony, PA 16037 (US). **VALENTAS, Louis, S.** [US/US]; 2408 Evans City Road, Harmony, PA 16037 (US). **SMITH, Todd, G.** [US/US]; 2408 Evans City Road, Harmony, PA 16037 (US).
- (74) Agent: **BANGOR, JR., Paul, D.**; Thorp Reed & Armstrong, LLP, One Oxford Centre, 14th Floor, 301 Grant Street, Pittsburgh, PA 15219-1425 (US).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: GAS AND PARTICULATE DELIVERY SYSTEM AND METHOD FOR METALLURGICAL VESSEL

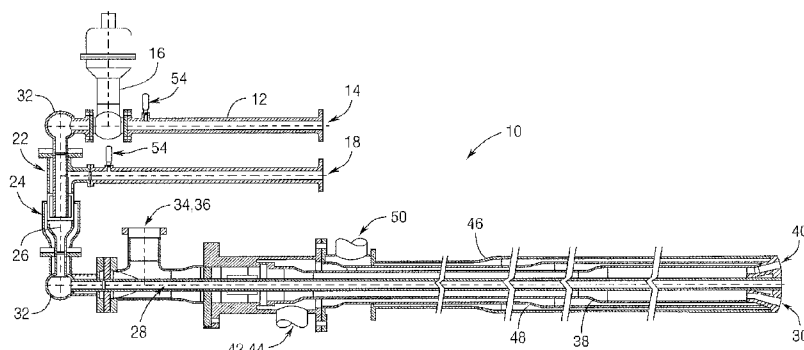


Fig. 1

(57) Abstract: A method and an apparatus for charging a particulate, for example lime, with a carrier gas, for example oxygen, through a lance into a metallurgical vessel or furnace. The apparatus comprises a metallurgical lance having an inner barrel communicating with the tip of the lance and a lance header, an outer tube having one end in open communication with the inner particulate barrel at the header and a second end sealed on the outside of a particulate inlet tube. The particulate inlet tube extends a first portion coaxially within the outer tube, and a second portion extends outside the outer tube. The second portion includes a shut-off valve. An auxiliary gas tube is in communication with the outer tube upstream of the particulate inlet tube opening within the outer tube.



TITLE: GAS AND PARTICULATE DELIVERY SYSTEM
AND METHOD FOR METALLURGICAL VESSEL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims benefit and priority from U.S. provisional application Ser. No. 61/480,982 entitled "GAS AND PARTICULATE DELIVERY SYSTEM AND METHOD FOR METALLURGICAL VESSEL," filed on April 29, 2011, the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION:

[0002] The present invention relates to injectors for injecting particulate matter and a gas into metallurgical refining vessels. The particulate material may be for example calcium oxide, the gas may be for example oxygen, and the metallurgical refining vessel may be for example a basic oxygen furnace (BOF), an electric arc furnace (EAF), or an argon-oxygen decarburization vessel (AOD).

BACKGROUND OF THE INVENTION

[0003] United States Patent Application Publication No. US 2009/0013827 entitled "CONDITIONED QUICKLIME FOR INJECTION TO A MOLTEN BATH OF A STEEL-MAKING VESSEL" discloses a method of producing steel using a steel-making vessel, where lime is used as a flux material that is blown, from above, into a steel-making bath along with an oxygen stream, providing a flux material composition of calcium oxide having a particle size of less than 250 mesh, which contains a flow aid material that is a polymeric siloxane, in an amount of less than 0.5 percent by weight of the calcium oxide, and where the flux material composition along with oxygen is injected through a lance into the steel-making bath contained in the steel-making vessel.

[0004] United States Patent No. 7,641,849 discloses an injector for injecting particulate material into metallurgical furnaces having the particulate entering into a chamber and a first gas also injected into the chamber at a supersonic velocity. The chamber has an outlet as a lance with a ceramic tubular barrel of a porous nature and an outer solid exterior coaxial barrel. A second gas

is supplied into the space between the barrels, the second gas passes through the inner barrel, mixes with the first gas and particulate, and the mixture is injected into the metallurgical furnace.

[0005] United States Patent No. 7,396,503 discloses a lance for injecting particulate matter into a metallurgical furnace. The lance has an inner barrel for introduction of a particulate, the inner barrel terminates at a first Laval nozzle for a shrouding gas in a coaxial barrel, and the first Laval nozzle terminates at a second Laval nozzle for a second shrouding gas in an outer barrel.

[0006] United States Patent No. 6,261,338 discloses a lance tip with numerous openings on the lance tip face, a first opening is a nozzle for passage of a gas jet stream, such as oxygen, while a second opening is for ejecting a mixture of powder and carrier gas, and a ring of openings are for injecting a ring of gaseous fuel to create a flame envelope around the first two openings. The powder mixture passage within the lance communicates with a source of powder and a carrier gas and communicates with the opening on the lance face. Powder and a small amount of a carrier gas are provided to an inner tube, moving the powder to an opening with an outer tube, where additional carrier gas is provided to accelerate the powder mixture. The outer tube communicates with the second opening.

[0007] The present invention in its various preferred embodiments described herein overcomes shortcomings of the prior art.

BRIEF SUMMARY OF THE INVENTION

[0008] The present invention will be used to inject particulate materials such as lime powder into a metallurgical furnace. The apparatus disclosed in **Figure 1** represents a metallurgical lance having an interior barrel for passage of a particulate in a carrier gas to the lance tip, an intermediate, co-axial barrel to contain and carry the same gas and/or a second gas to the lance tip, and an exterior barrel to contain and carry a coolant for the lance. A particulate inlet tube carrying a particulate such as lime comes to an opening with an outer tube where a carrier gas is provided to accelerate the particulate mixture. The apparatus has a valve in the particulate inlet tube to isolate the particulate source. The figure illustrates the use of wear boxes to reduce abrasion where a turn in the tube is necessary. **Figure 2** illustrates a dual pressure regulated supply for the carrier gas. The lime or other particulate enters into the particulate inlet tube, past the valve, the particulate mixes and is accelerated by the carrier gas, after passing through wear boxes; the particulate passes through the interior wear barrel of the lance and into the furnace.

The dual pressure regulator allows for higher pressure during purge and lower pressure during particulate injection.

[0009] A first aspect of the present invention includes a method for charging a particulate to a metallurgical vessel through a lance system comprising injecting through the lance system a low pressure carrier gas such that the gas enters the metallurgical vessel; feeding particulate to the low pressure carrier gas such that the gas carries the particulate into the metallurgical vessel; stopping the feeding of the particulate; and purging the lance system with a high pressure carrier gas. In some embodiments, the method further comprises the step of monitoring and modulating the carrier gas flow and particulate flow. In preferred embodiments have the particulate as lime and the carrier gas as oxygen. In other preferred embodiments, the method has a low pressure carrier gas regulated by first and second regulating valves; and a high pressure carrier regulated by the first regulating valve and a by-pass valve. In still other preferred embodiments, the low pressure carrier gas and the high pressure carrier gas are regulated by a single pressure regulating valve. And in other preferred embodiments, the low pressure carrier gas and the high pressure carrier gas are modulated by a single pressure regulating valve.

[0010] A second aspect of the present invention is an apparatus for charging a particulate to a metallurgical vessel through a lance system comprising a metallurgical lance having an inner barrel communicating with a tip of the lance and a header of the lance; an outer tube having a first end in open communication with the inner barrel at the header and a second end sealed on the outside of a particulate inlet tube; the particulate inlet tube extending a first portion co-axially within the outer tube from the outer tube second end, and a second portion extending outside the outer tube; the second portion of the particulate inlet tube having a shut-off valve; an auxiliary gas tube having a first end in open communication with the outer tube, wherein the open communication is positioned between the outer tube second sealed end and adjacent to the particulate inlet tube first portion, and the second end of the auxiliary gas tube in communication with at least one pressure regulating valve.

[0011] A preferred embodiment has at least one wear box in the particulate inlet tube. Another preferred embodiment has at least one wear box in the outer tube. In some embodiments, there is at least one pressure regulating valve comprises only one pressure regulating valve. In still other embodiments, the at least one pressure regulating valve further comprises a high pressure regulating valve, a low pressure regulating valve downstream of the high pressure regulating

valve, and a by-pass valve to by-pass the low pressure regulating valve. In some embodiments, the apparatus further comprises a particulate flow meter in the particulate inlet tube. In other embodiments, the apparatus further comprises a a gas flow meter in the auxiliary gas tube. In still other embodiments, the at least one pressure regulating valve is at a location remote from the metallurgical lance.

BRIEF DESCRIPTION THE DRAWINGS

[0012] FIG. 1 shows the particulate injection lance and header, the header having a particulate inlet tube, particulate valve, carrier gas inlet tube, wear boxes, and the lance having an inner wear barrel, oxygen inlet, and coolant passages.

[0013] FIG. 2 shows the dual pressure regulated gas supply having bypass valves to allow stopped flow, low flow, and high flow to the carrier gas line.

[0014] FIG. 3 shows in schematic a preferred embodiment of a system according to the present invention.

[0015] FIG. 4 shows a particulate injection lances according to the present invention.

[0016] FIG. 5 shows a close-up of a particulate roto-feed unit according to the present invention and a diagram for scale.

[0017] FIG. 6 shows an example of a typical BOP vessel of a flux system.

[0018] FIG. 7 shows an example of a typical BOP vessel of a lance system according to the present invention.

[0019] FIG. 8 shows a center hole oxygen lance according to the present invention.

[0020] FIG. 9 shows a basic oxygen process with lime injection equipment according to the present invention and a diagram for scale.

[0021] FIG. 10 shows a roto-feed feeder according to the present invention.

DETAILED DESCRIPTION

[0022] It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, other steps/elements that may be well known. Those of ordinary skill in the art will recognize that other steps/elements are desirable and/or required in order to implement the present invention. However, because such

steps/elements are well known in the art, and because they do not facilitate a better understanding of the present invention, a discussion of such steps/elements is not provided herein. The detailed description of the present invention and the preferred embodiment(s) thereof are set forth in detail below with reference to the attached drawings.

[0023] Referring now to the drawings, **FIGS. 1 - 3** illustrate a preferred embodiment according to the present invention for a system to inject a gas/particulate mixture such as an oxygen/calcium oxide mixture into a metallurgical furnace.

[0024] **FIG. 1** represents a preferred embodiment of a metallurgical lance apparatus **10** having particulate inlet tube **12** for introduction of a particulate **14**, for example calcium oxide having a particle size of less than 250 mesh containing a flow aid material that is an organic siloxane, in an amount of less than 0.5 percent by weight of the calcium oxide, into the system. The particulate inlet tube has a shut-off valve **16** to allow isolation of the first tube **12** from the other components of the lance apparatus **10**. The shut-off valve **16** avoids back pressure to the particulate input feed **14** (**FIG. 2**) or feed unit **80** (**FIG. 3**) which may be a roto-feed lime dispenser.

[0025] A carrier gas **18**, for example oxygen, enters the lance apparatus **10** through an auxiliary gas tube **20**. The auxiliary gas tube **20** communicates with an outer tube **22** coaxial with the particulate tube **12**. The particulate **14** from the particulate inlet tube **12** and the carrier gas **18** from the outer tube **22** mix in a chamber **24**, where the carrier gas **18** flows, carrying the particulate **14** as a combined gas/particulate mix **26**. The combined mix **26** enters an inner wear barrel **28** and exits at an aperture **30**.

[0026] Preferably the particulate inlet tube **12** and outer tube **22** are arranged in a coaxial manner to allow the mix of the particulate **14** and carrier gas **18** to reduce abrasion along the gas/particulate mix path **26**. As the path for the particulate **14** and combined mix **26** pass through the tubes **12** and **24** and through turns, wear boxes **32** are preferably employed to reduce abrasion.

[0027] Oxygen **34** enters the lance apparatus **10** through an oxygen inlet **36**. The oxygen **34** travels through the lance apparatus **10**, is contained between the intermediate barrel **38** and the inner wear barrel **28**, and exits through nozzles **40**. Coolant **42**, for example water, enters the lance apparatus **10** at coolant inlet **44**, is contained and passes through passages defined by exterior barrels **46** and **48**. The coolant **42** exits the lance apparatus **10** through coolant outlet **50**.

[0028] In some embodiments, the auxiliary gas tube 20 has an installed carrier gas flow meter 52. In other embodiments, the particulate inlet tube 12 has an installed particulate flow meter 54. In preferred embodiments, the carrier gas flow meter 52 and the particulate flow meter 54 are used to monitor and modulate the ideal pressure and flow during particulate injection and purge sequences.

[0029] FIG. 2 represents a carrier gas skid 56 for regulating the flow of the carrier gas 18. The carrier gas 18 from a carrier gas supply enters the gas skid 56 at aperture 58 (typically at about a pressure of 250 psi). The carrier gas supply may come from an independent auxiliary feed source (not shown) or from the oxygen inlet 36. The carrier gas 18 passes through a first pressure regulating valve 60, which may reduce the pressure down to 150 psi from 250 psi. The carrier gas 18 then passes through either by-pass valve 62 or second pressure regulating valve 66 (preferably reducing pressure further to about 30 psi) before exiting the gas skid 56 at skid exit aperture 64. In some embodiments, the carrier gas 18 is oxygen 34 from an external source. In other embodiments, the carrier gas 18 is oxygen 34 by communication with the main oxygen supply 34, 36.

[0030] In a preferred embodiment, the carrier gas pressure is regulated by the first and second pressure regulating valves 60 and 66 and a by-pass valve 62. In a more preferred embodiment, a single modulating pressure regulative valve 60 regulates the carrier gas pressure without pressure regulating valve 66 and by-pass valve 62.

[0031] The overall embodiment has a dual pressure regulated carrier gas supply 18 to the auxiliary gas tube 20. The dual pressure created by the carrier gas 18 passing as high pressure through by-pass valve 62 or as low pressure through the second pressure regulating valve 66. This allows for lower pressure to be used during particulate injection sequences and a higher pressure to be used to purge the channel of particulate 14 from chamber 24 to the particulate outlet 30 when the particulate injection sequence is not running. During an entire blow sequence, at least one valve, 62 or 66 remains open to maintain positive pressure and reduce plugging issues due to slag ingestion into opening 30.

[0032] In some embodiments, the gas skid 56 is directly attached to the auxiliary gas tube 20. In other preferred embodiments, the gas skid 56 is placed at a remote location as shown in FIG. 3. FIG. 3 illustrates an embodiment wherein a lime feed unit 80 is on a lower floor of a building 90. The lime feed unit 80 is connected by hard piping 82 and/or flex hose 86 to a lance

apparatus **10** two floors above **92**. In the embodiment, the gas skid **56** is on an intermediate floor **94**, the gas connected through piping or flex hose **88** to the lance apparatus **10**.

[0033] In use, the metallurgical lance system **10** is installed in a metallurgical furnace. The shut-off valve **16** is closed. The particulate inlet tube **12** is connected to a source of particulate **14** such as lime particulate and oxygen gas mixture. The carrier gas skid **56** is attached to/from the skid exit aperture **64** to the auxiliary gas tube **20** as shown in **FIG. 3**. In a first embodiment of a method for delivery of a gas/particulate mixture to a metallurgical vessel according to the present invention comprises the steps comprising: injecting a low pressure carrier gas **18** through a lance system **10** such that the gas **18** enter the metallurgical furnace, feeding particulate to the low pressure carrier gas such that the gas injects the particulate **14** into the metallurgical furnace, stopping feed of the particulate **14** to the carrier gas, increasing the pressure of the carrier gas **18** to purge the lance system **10**.

[0034] In another preferred embodiment of the present invention, the method for delivery of a gas/particulate mixture to a metallurgical vessel comprises the steps of: injecting through a lance system **10** a low pressure carrier gas **18** such that the gas **18** enter the metallurgical vessel, feeding particulate to the low pressure carrier gas such that the gas carries the particulate **14** into the metallurgical vessel, monitoring and modulating the carrier gas flow and particulate flow, stopping feed of the particulate **14**, increasing the pressure of the carrier gas **18** to purge the lance system **10**, monitoring and modulating the carrier gas flow, decreasing the pressure of the carrier gas **18**, and monitoring and modulating the carrier gas flow, and injecting the lance system **10** with the low pressure carrier gas **18**.

[0035] In yet another preferred embodiment of the method, lime particulate is charged to a metallurgical vessel using oxygen as a carrier gas, the steps comprising: charging lime particulate **14** to the metallurgical lance system **10** through the particulate inlet tube **12** up to the shut-off valve **16**, charging oxygen as the carrier gas **18** through the first pressure regulating valve **60** and second pressure regulating valve **66** producing a continuous low pressure feed of carrier gas **18** through the lance system **10** to the particulate outlet **30**, then opening the shut-off valve **16**, mixing in a linear fashion the particulate **14** and the carrier gas **18**, closing shut-off valve **16**, opening by-pass valve **62** to purge the system, then closing by-pass valve **62**.

[0036] In another preferred embodiment of the method, lime particulate is charged to a metallurgical vessel using oxygen as a carrier gas, the steps comprising: charging lime powder

14 to the metallurgical lance system 10 through the particulate inlet tube 12 up to the shut-off valve 16, charging oxygen as the carrier gas 18 through the first pressure regulating valve 60 and second pressure regulating valve 66 producing a continuous low pressure feed of carrier gas 18 through the lance system 10 to the particulate outlet 30, monitoring the carrier gas 18 using a carrier gas flow meter 52 while modulating the carrier gas flow with the second pressure regulatory valve 66, then opening the shut-off valve 16, mixing in a linear fashion the particulate 14 and the carrier gas 18, monitoring the carrier gas 18 using a carrier gas flow meter 52 while modulating the carrier gas flow with the second pressure regulatory valve 66 and monitoring and modulating the particulate flow using a particulate flow meter 54, closing shut-off valve 16, opening by-pass valve 62 to purge the system, then closing by-pass valve 62.

[0037] FIG. 4 illustrates a particulate injection lance according to the present invention. The center figure is a cut-away view of the new lance tip design, with a preferred embodiment of a two or three inch inside diameter aperture 30. FIG. 4 also illustrates two other preferred embodiments with nozzles 40 numbering four 102 or five 104.

[0038] FIG. 5 illustrates a particulate roto-feed unit 106. Lime enters the roto-feed unit from above 108. The FIG. 5 inset illustrates the location of the particulate roto-feed unit 106. The lime exits the roto-feed unit through piping 110.

[0039] FIG. 6 illustrates an example of a typical BOP vessel with a flux system as would be understood by a person of skill in the art. In a preferred embodiment, the lime is sized at approximately 2 inch by ¼ inch. In this embodiment, the lime handling system dictates a pebble product. Lime is a friable material and will break down when handled. Lime is fed into the process in large hoppers 112 from a weigh hopper 114 using gravity.

[0040] FIG. 7 illustrates an example of a typical BOP vessel with a lance system as would be understood by a person of skill in the art. Lime is added to the process after the start of the oxygen blow to allow the oxidation reaction to start (ignition). Late lime addition, bulk charging and pebble size can all inhibit quick formation of a basic slag. Slag formation rate control is important to optimize the BOP process.

[0041] FIG. 8 illustrates an example of a center hole (aperture 30) oxygen lance. A typical lance diameter is 10 or 12 inches. A proportioned center hole (aperture 30) is 2 or 3 inches. The close-up shows a preferred embodiment having four nozzles 40. The inset shows a preferred oxygen lance apparatus 10 positioning.

[0042] FIG. 9 illustrates an example of a basic oxygen process with lime injection equipment as would be understood by a person of skill in the art. In this preferred embodiment, lime injection equipment of FIG. 5 is illustrated.

[0043] FIG. 10 is a schematic of a roto-feed feeder unit 106. In a preferred embodiment, material enters through a dispensing vessel 116. An agitator 118 connected to a motor 120 through a gearbox 122 and rotor 124 moves the material. The material flows through a housing 126, accompanied by a gas from a gas conveying inlet 128. The material and gas exit the housing 126 through piping 110.

[0044] In use, the system has a dual pressure regulated oxygen supply to the Lime Pipe (inner wear barrel 28 of a particulate injection lance) allowing for lower pressure (30 PSI) to be used during Lime Injection sequences, and a higher pressure (150 PSI) to be used to purge the wear barrel 28 when the Lime Injection sequence is not running. The oxygen flow to the wear barrel 28 preferably is continuous through the entire blow sequence, maintaining positive pressure and reducing plugging issues due to slag ingestion.

[0045] Oxygen can be supplied either by an independent auxiliary gas tube 20, or from a port included on the oxygen inlet 36 on the lance apparatus 10. Oxygen pressure regulating valves 60 and 66 can be either mounted on the lime injection top adapter, on the lance 10, or on a remote skid 56 located in the shop wherever it is convenient. Oxygen pressure can either be regulated by two pressure regulators/pressure regulating valves 60 and 66 (one low pressure and one high pressure) and a bypass valve 62 to determine which pressure is used, or by a single modulating pressure regulating valve.

[0046] The lime (or particulate) injection top adapter is designed to merge the lime and oxygen flows in a linear fashion, reducing potential wear points due to abrasion along the lime flow path, while helping to drive the lime through the lance. Special wear boxes 32 reduce wearing issues due to abrasion where a 90 degree turn in lime flow is required. Oxygen and lime flow pressures may be monitored at the lance, allowing the user to modulate the oxygen pressure valves to ensure ideal pressure and flow during Lime Injection and purge sequences. The lime injection top adapter includes a lime shut-off valve 16, allowing the lance to be isolated from the lime feed unit to avoid back pressure to the feed unit (preferably made of stainless steel).

[0047] A replaceable wear pipe 28 may be used through the center of the lance to flow the particulate/lime, allowing for easy replacement if the pipe fails, and providing protection from

wearing directly on the lance piping. Preferably, the lime injection top adapter is easily removable, and can be retrofitted to most lance designs. In addition to lime, the system can be used for injection of other materials, such as ore or carbon. The carrying gas can also vary to be used with argon, air, nitrogen or oxygen.

[0048] Organic siloxane reduces surface charges, especially for dolomitic lime with sizing that is about 250 mesh. When lime product is added, a typical density of the pulverized lime product is about 42 lbs/ft³ when flowing and about 60 lbs/ft³ when settled and treated. The lime product during addition has sizing similar to flour or talcum powder – but appears liquid. The lime product flows easily and does not hydrate as other powdered lime and thus there is no plugging. The lime can flow at about 2,000 lbs/min in 3” pipe situated in the lance.

[0049] Preferably, the design of the lance is a 12-inch diameter, 4-hole oxygen lance with a 2” or 3” diameter center hole for injection purposes that provides an oxygen shroud around powdered lime. Other preferred lances comprise a 4- or 5-hole lance with center holes to deliver oxygen to the process.

[0050] Nitrogen or oxygen can be used to purge the tank. Oxygen is the carrier gas for lime. Preferably, stainless steel flex-hose is used to convey the lime and carrier gas from the tank to the lance.

[0051] The process is an improvement over current technology for some or all of the following. The oxygen jets will act as a carrier for the powdered lime directly to the slag/steel interface. There is an expected reduction in process heat time related to the dissolution rate optimization of the lime addition. The process is flexible, as high calcium or dolomitic lime may be added when desired. With the improvements, there is expected a reduction in lime consumption by about 5 to 10 percent. The lance tip life is expected to be longer as the lime will shield the tip from bath radiation. Further, the distribution density of the powdered lime material will create less of a heat sink.

[0052] In addition, there will be metallurgical benefits of some or all of the following. Reactive lime at the oxidation reaction site will improve acid slag neutralization. There will be an improved dissolution rate optimization due to the larger surface area of the added materials. The control of the slag basicity will benefit refractory improvements. Further, process improvements will be available from introduction of the lime at the oxidation reaction site to improve early phosphorus removal, and to improve slag basicity and cool for late phosphorus removal.

[0053] Also, environmental benefits are expected from the present invention. Lime dust on the BOP operating floors and off gas will be reduced, improving safety and environmental concerns. There will be a concomitant reduction in cost associated with emissions management.

[0054] A controllable feed provides a steady, feed of material into a process, and the injection rate is adjustable and can be controlled to meet the needs of the process. As opposed to a volumetric feeder, the injection rate may be more accurately controlled. In addition, materials may be injected against pressure into a pressurized environment. Injection systems as described can be integrated into a larger process plant, and a wide range of materials may be conveyed therein.

[0055] While the present disclosure has been described in connection with preferred embodiments thereof, those of ordinary skill in the art will recognize that many modifications and variations are possible. The present disclosure is intended to be limited only by the following claims and not by the foregoing description which is intended to set forth the presently preferred embodiment.

[0056] It is to be understood that the descriptions of the present disclosure have been simplified to illustrate elements that are relevant for a clear understanding of the present disclosure, while eliminating, for purposes of clarity, other elements that may be well known. Those of ordinary skill in the art will recognize that other elements are desirable and/or required in order to implement the present disclosure. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the present disclosure, a discussion of such elements is not provided herein. Additionally, it is to be understood that the present disclosure is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the description.

CLAIMS

1. A method for charging a particulate to a metallurgical vessel through a lance system comprising:
 - injecting through the lance system a low pressure carrier gas such that the gas enters the metallurgical vessel;
 - feeding particulate to the low pressure carrier gas such that the gas carries the particulate into the metallurgical vessel;
 - stopping the feeding of the particulate; and
 - purging the lance system with a high pressure carrier gas.
2. The method of claim 1, further comprising monitoring and modulating the carrier gas flow and particulate flow.
3. The method of claim 1, wherein the particulate is lime and the carrier gas is oxygen.
4. The method of claim 1, wherein the low pressure carrier gas is regulated by first and second regulating valves; and the high pressure carrier gas is regulated by the first regulating valve and a by-pass valve.
5. The method of claim 1, wherein the low pressure carrier gas and the high pressure carrier gas are regulated by a single pressure regulating valve.
6. The method of claim 5, wherein the low pressure carrier gas and the high pressure carrier gas are modulated by a single pressure regulating valve.
7. An apparatus for charging a particulate to a metallurgical vessel through a lance system comprising:
 - a metallurgical lance having a inner barrel communicating with a tip of the lance and a header of the lance;
 - an outer tube having a first end in open communication with the inner barrel at the header and a second end sealed on the outside of a particulate inlet tube;
 - the particulate inlet tube extending a first portion co-axially within the outer tube from the outer tube second end, and a second portion extending outside the outer tube;
 - the second portion of the particulate inlet tube having a shut-off valve;
 - an auxiliary gas tube having a first end in open communication with the outer tube, wherein the open communication is positioned between the outer tube second sealed end and adjacent to the particulate inlet tube first portion, and the second

- end of the auxiliary gas tube in communication with at least one pressure regulating valve.
8. The apparatus for charging a particulate of Claim 7, further comprising at least one wear box in the particulate inlet tube.
 9. The apparatus for charging a particulate of Claim 7, further comprising at least one wear box in the outer tube.
 10. The apparatus for charging a particulate of Claim 7, wherein the at least one pressure regulating valve comprises only one pressure regulating valve.
 11. The apparatus for charging a particulate of Claim 7, wherein the at least one pressure regulating valve further comprises a high pressure regulating valve, a low pressure regulating valve downstream of the high pressure regulating valve, and a by-pass valve to by-pass the low pressure regulating valve.
 12. The apparatus for charging a particulate of Claim 7, further comprising a particulate flow meter in the particulate inlet tube.
 13. The apparatus for charging a particulate of Claim 7, further comprising a gas flow meter in the auxiliary gas tube.
 14. The apparatus for charging a particulate of Claim 7, wherein the at least one pressure regulating valve is at a location remote from the metallurgical lance.

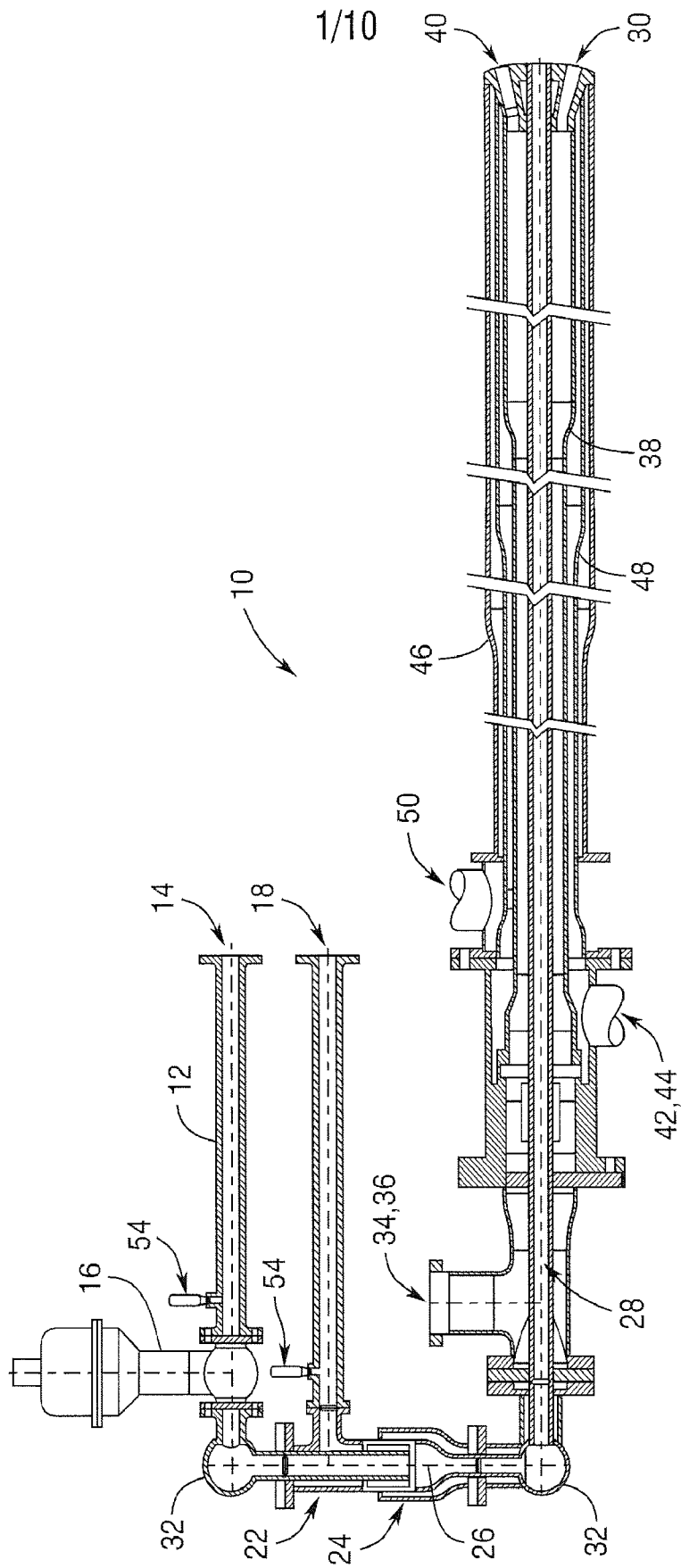


Fig. 1

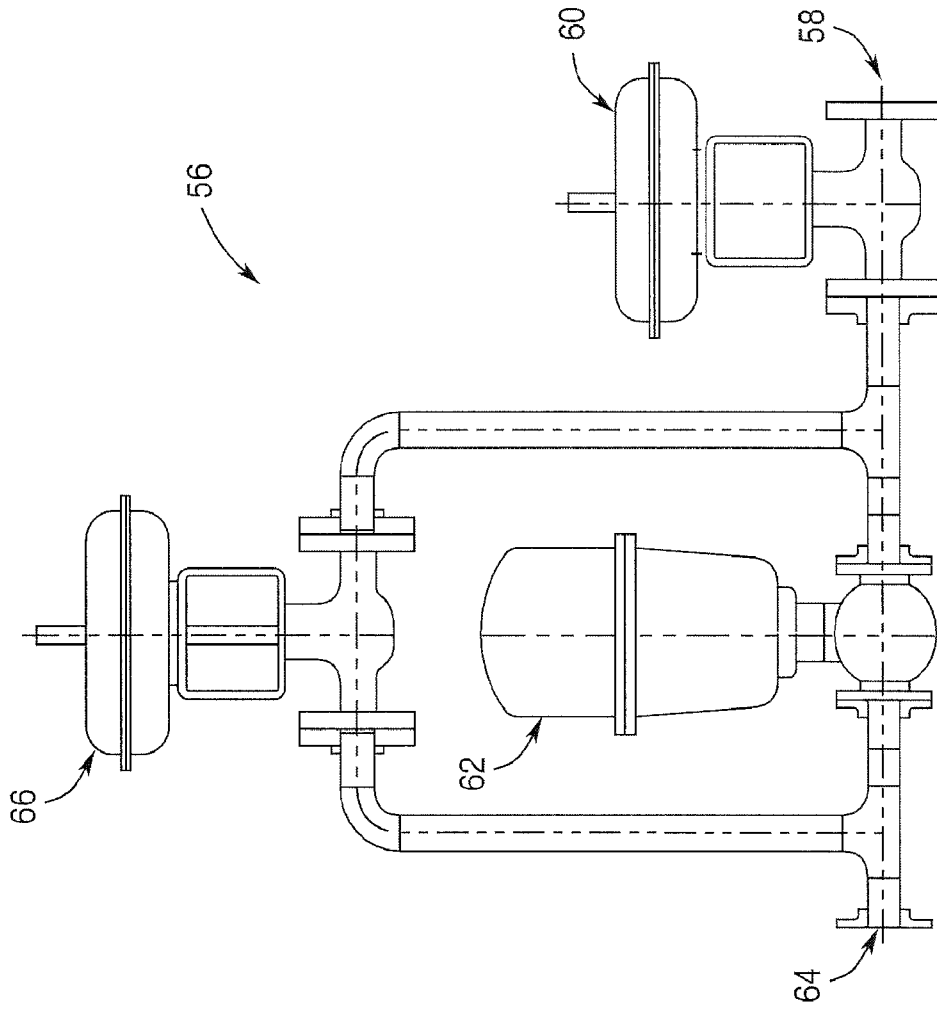


Fig. 2

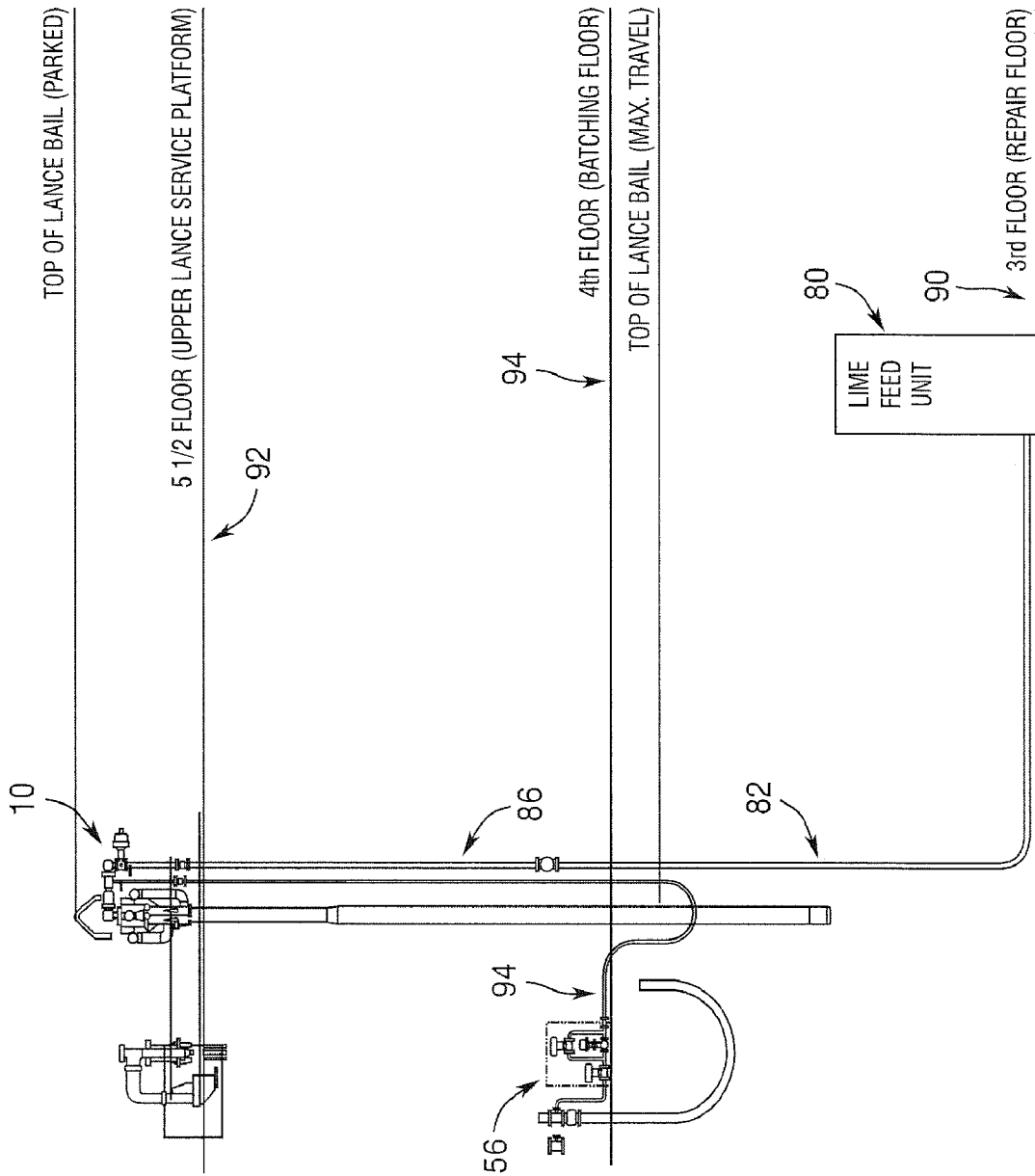


Fig. 3

4/10

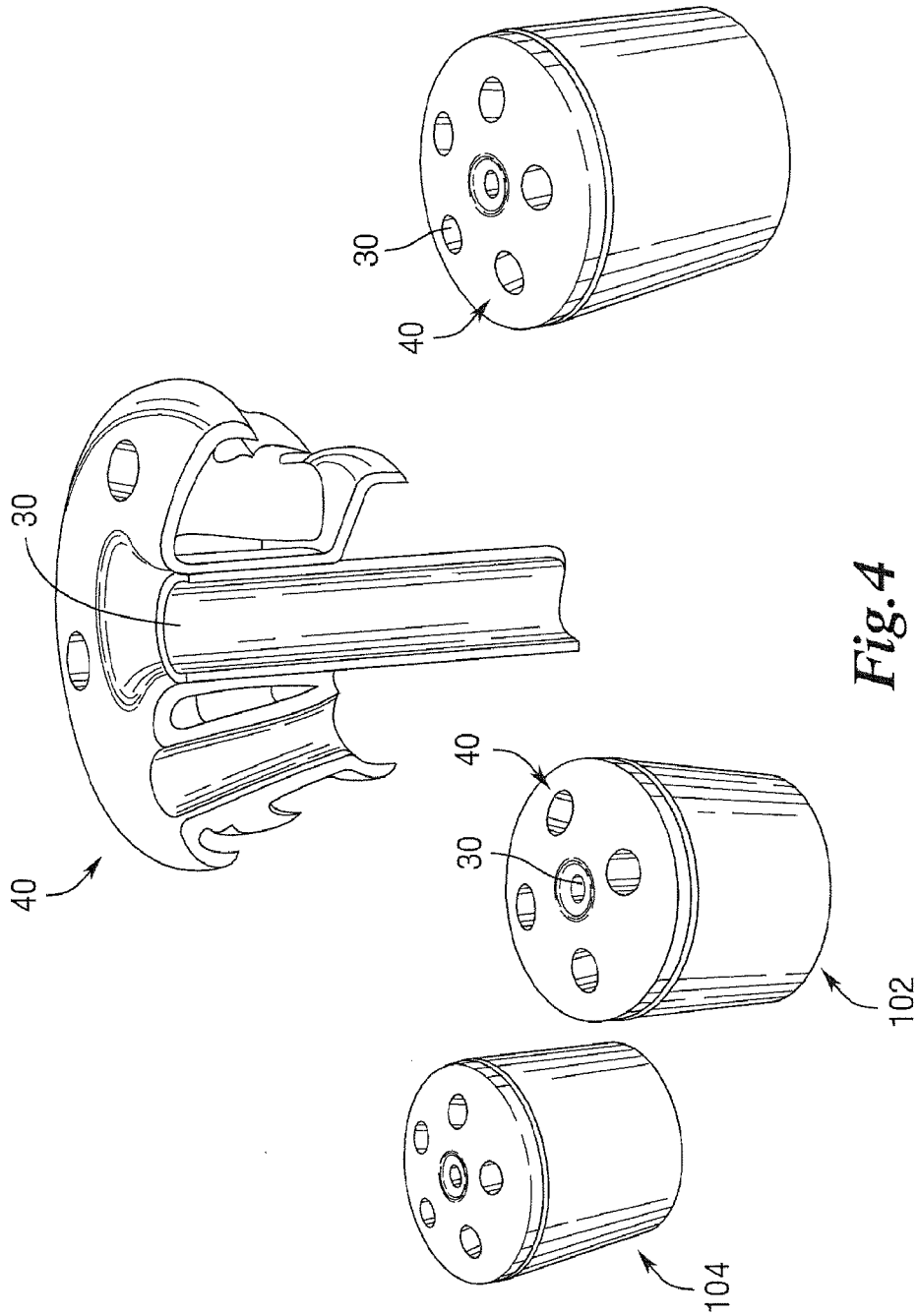


Fig. 4

5/10

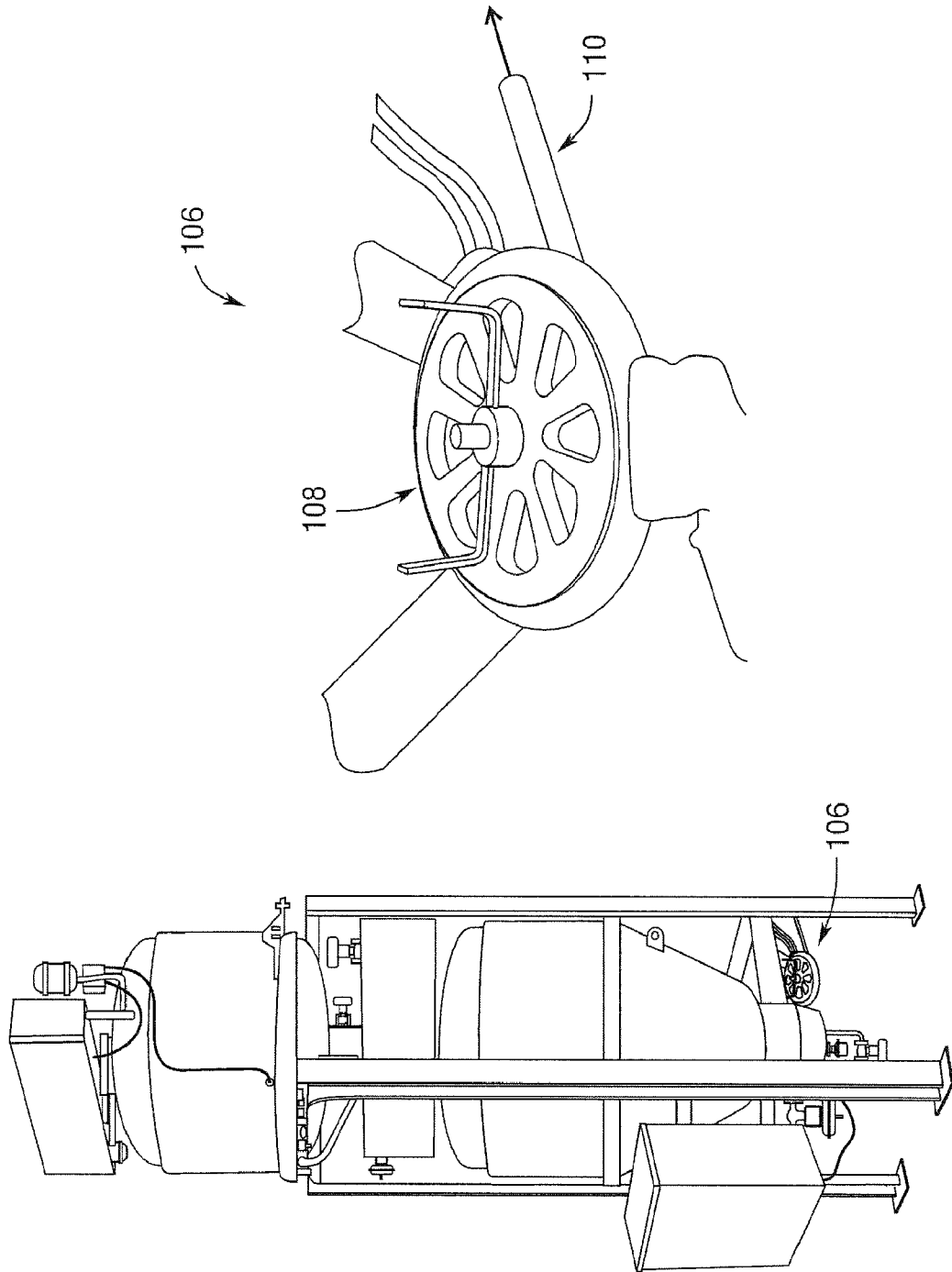


Fig.5

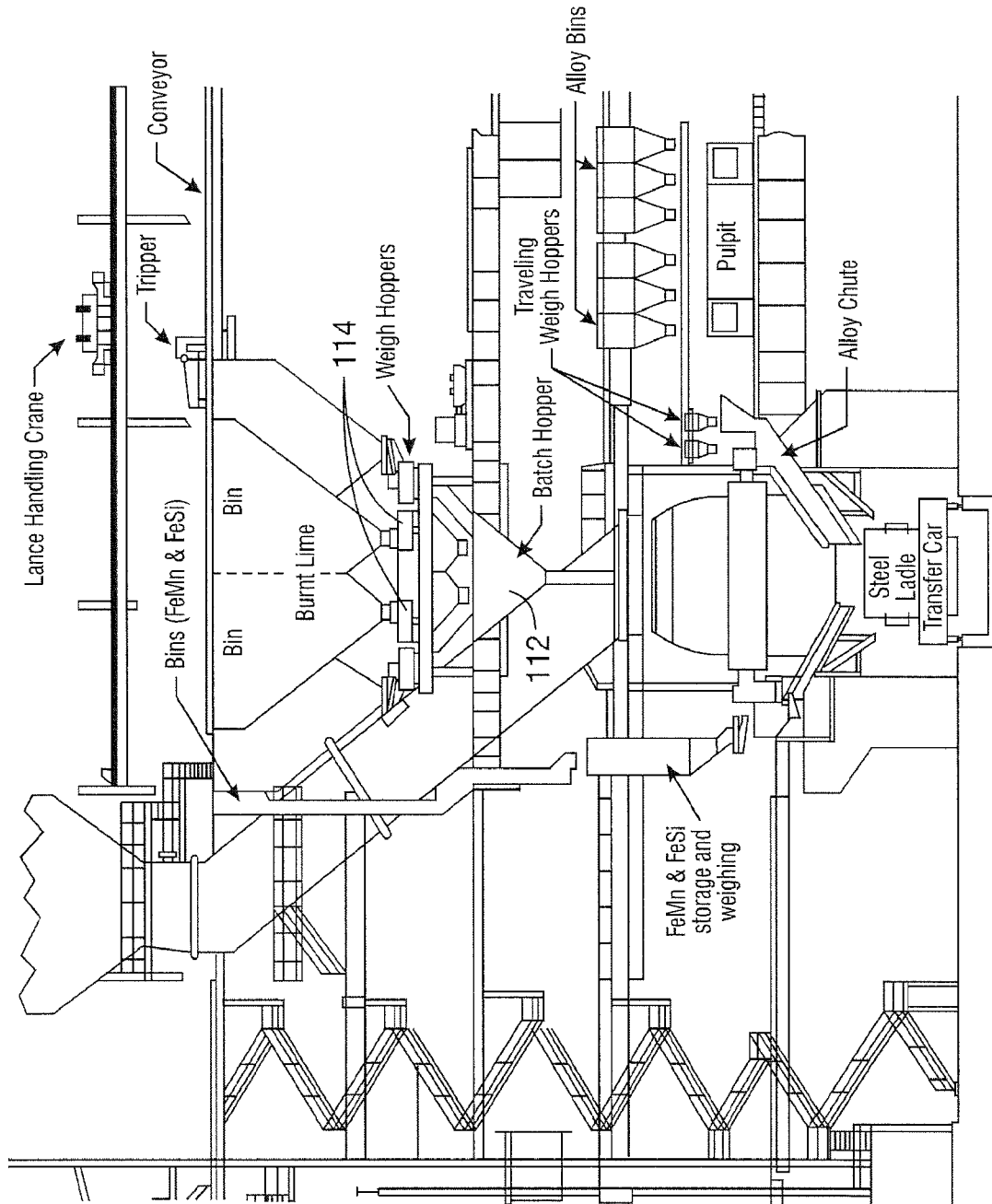


Fig.6

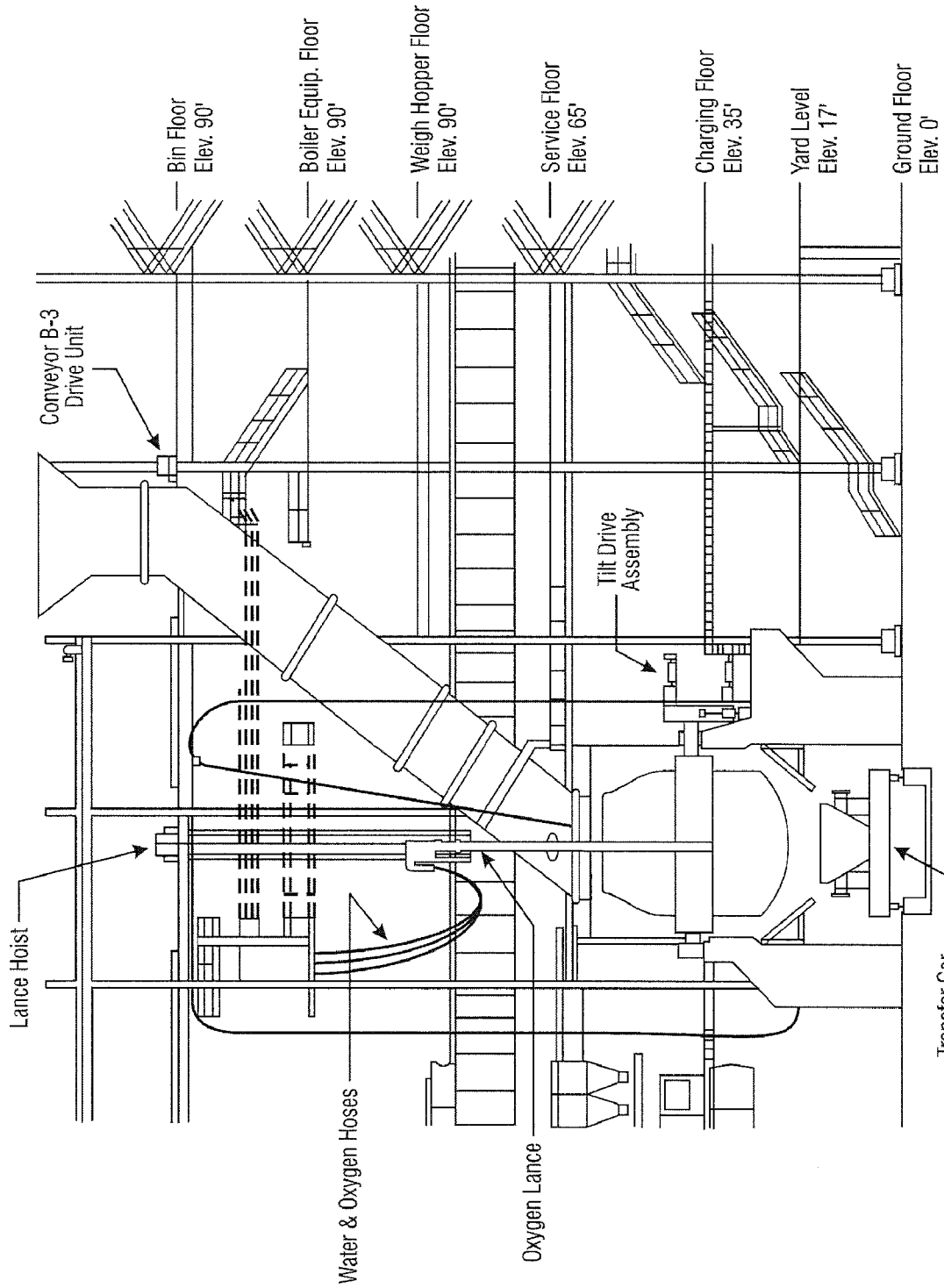


Fig. 7

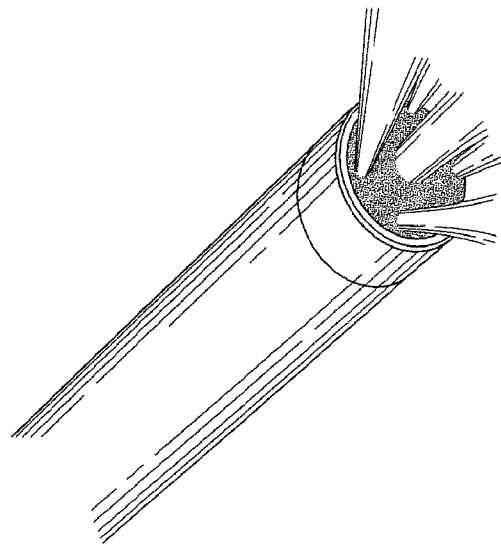
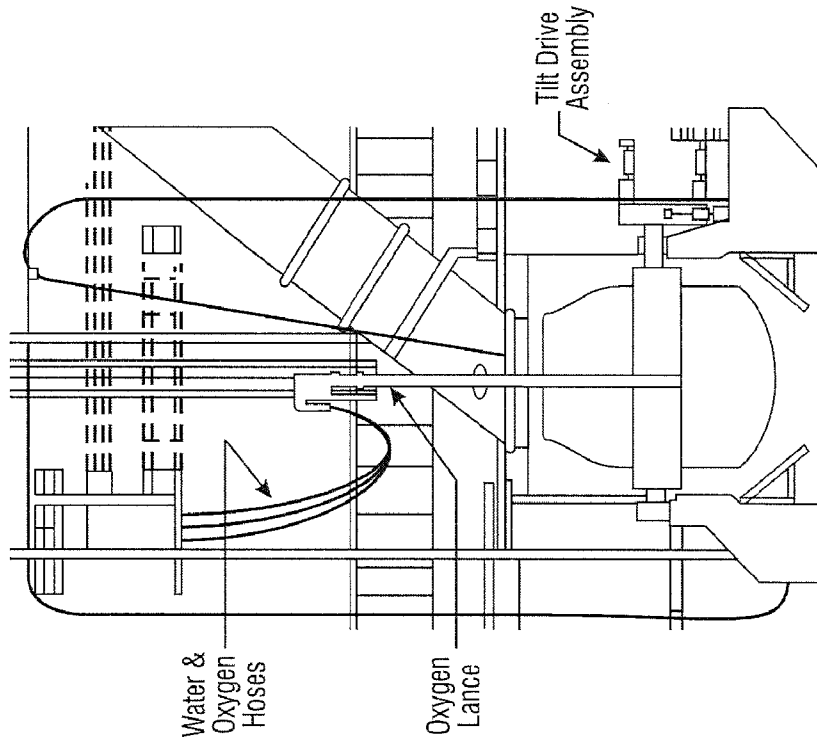


Fig.8

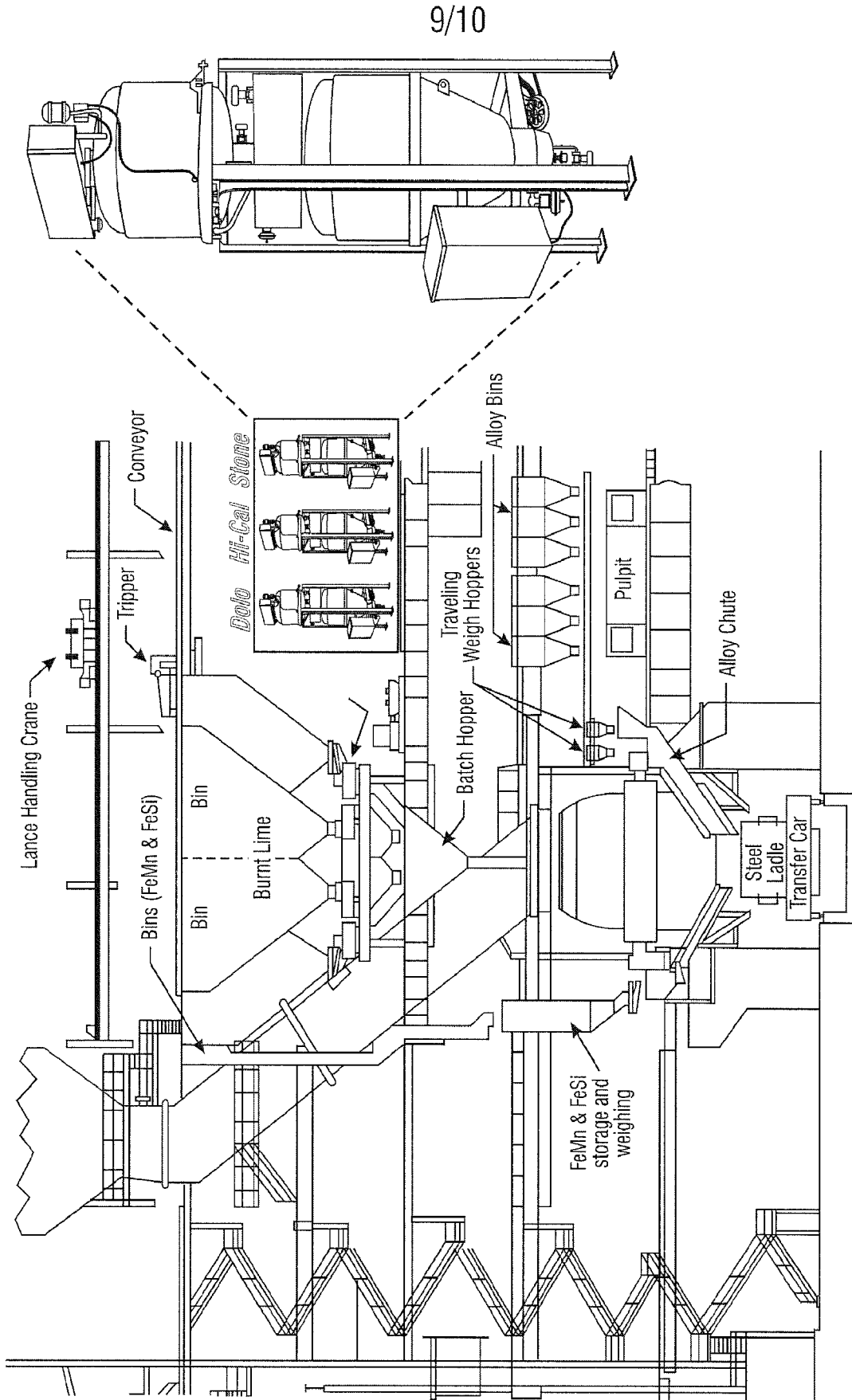


Fig.9

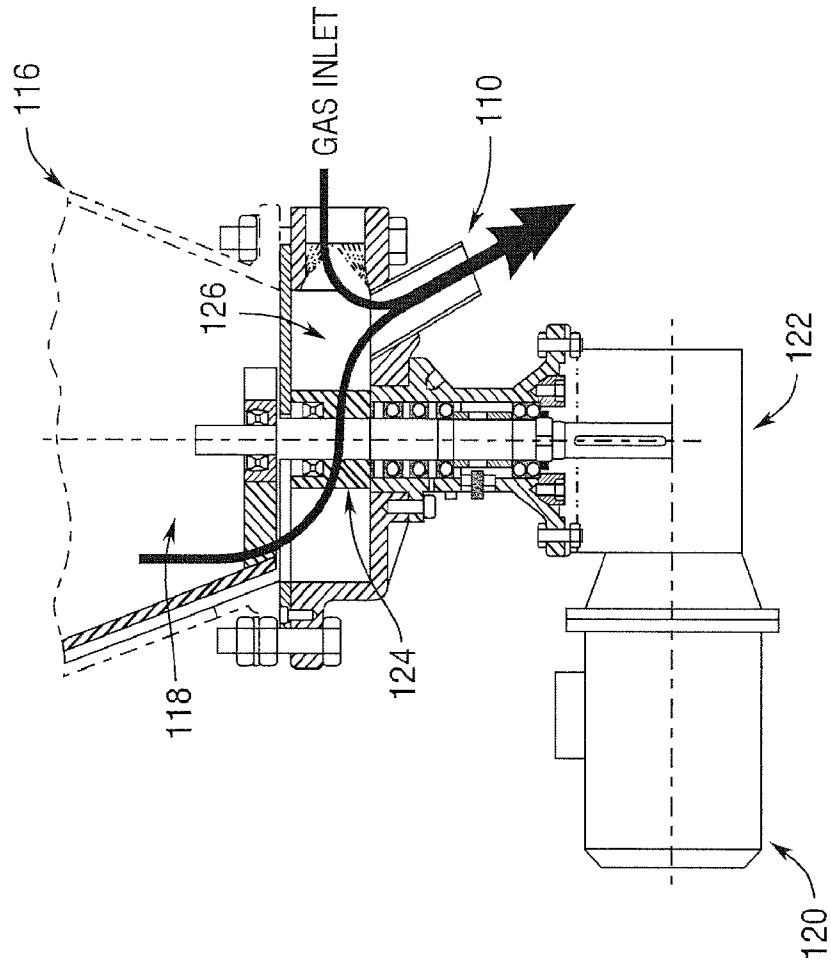


Fig. 10