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(54) **TUYERE FOR OXYGEN BLAST FURNACE CONVERTER SYSTEM**

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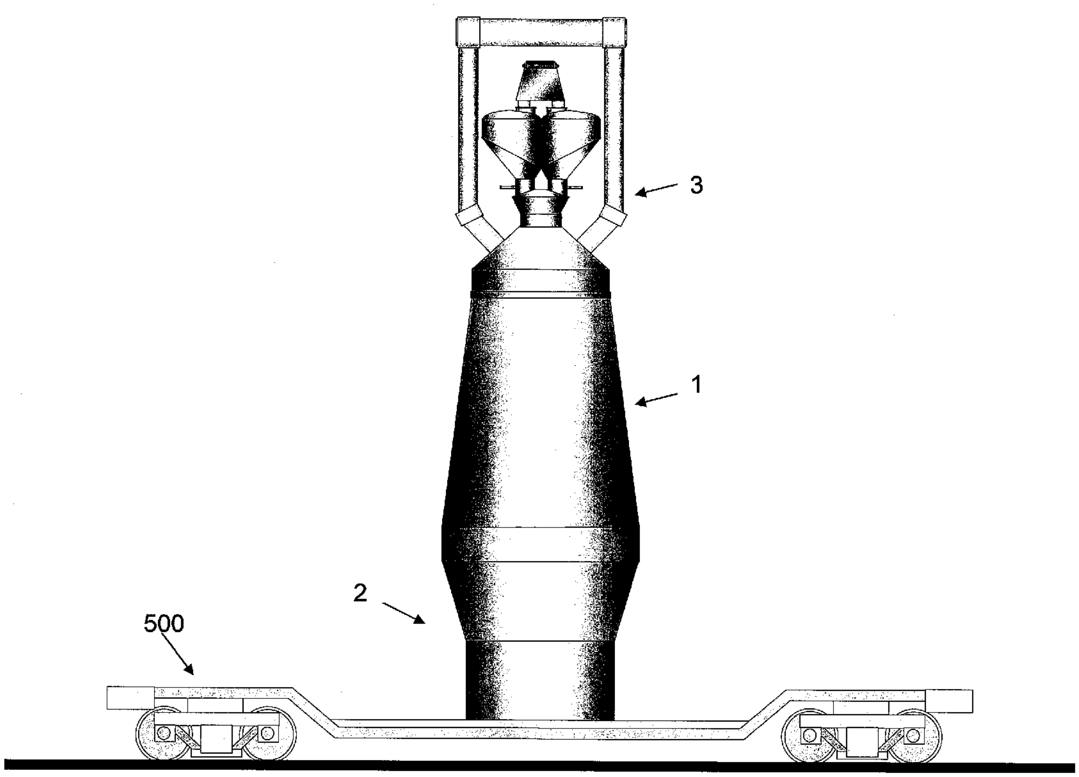
(57) **ABSTRACT**

A tuyere for an oxygen blast furnace has a body and a first conduit extending through the body. The first conduit is adapted to receive a medium at one end of the conduit and discharge the medium at a second end of the conduit through at least one discharge nozzle. A second conduit can be arranged concentrically around the first conduit and is adapted to receive a medium and discharge the medium through at least one discharge nozzle. In another aspect, a portable oxygen blast furnace system includes oxygen blast furnace secured to a railcar. The portable furnace system can be transported by rail for processing material at remote locations.



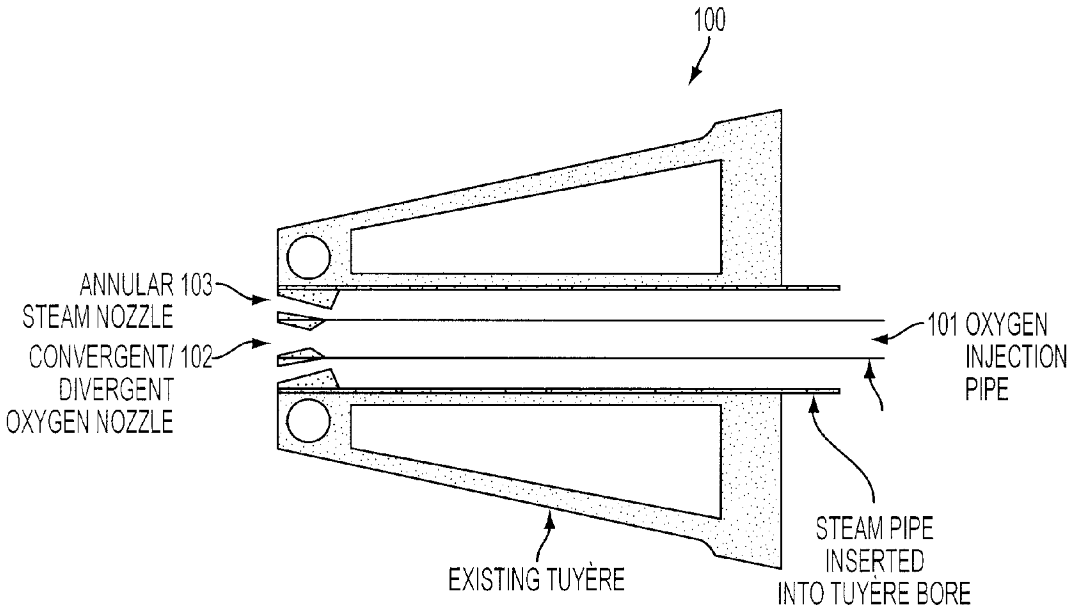

100
ANNULAR 103
STEAM NOZZLE
CONVERGENT/ 102
DIVERGENT
OXYGEN NOZZLE
101 OXYGEN
INJECTION
PIPE
EXISTING TUYÈRE
STEAM PIPE
INSERTED
INTO TUYÈRE BORE

FIG. 1

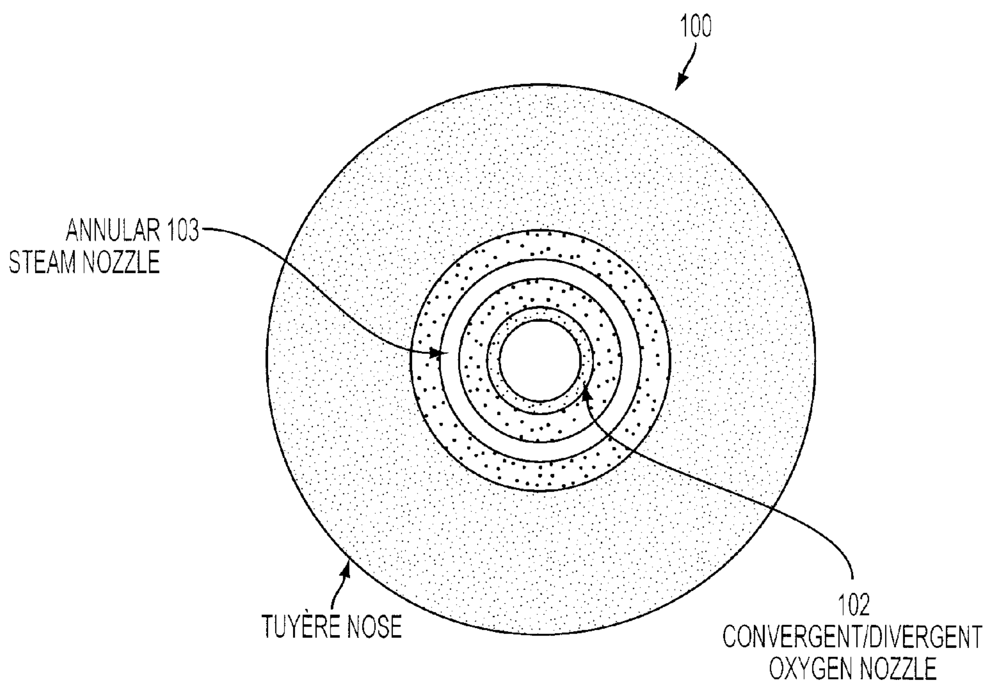

100
ANNULAR 103
STEAM NOZZLE
TUYÈRE NOSE
102
CONVERGENT/DIVERGENT
OXYGEN NOZZLE

FIG. 2

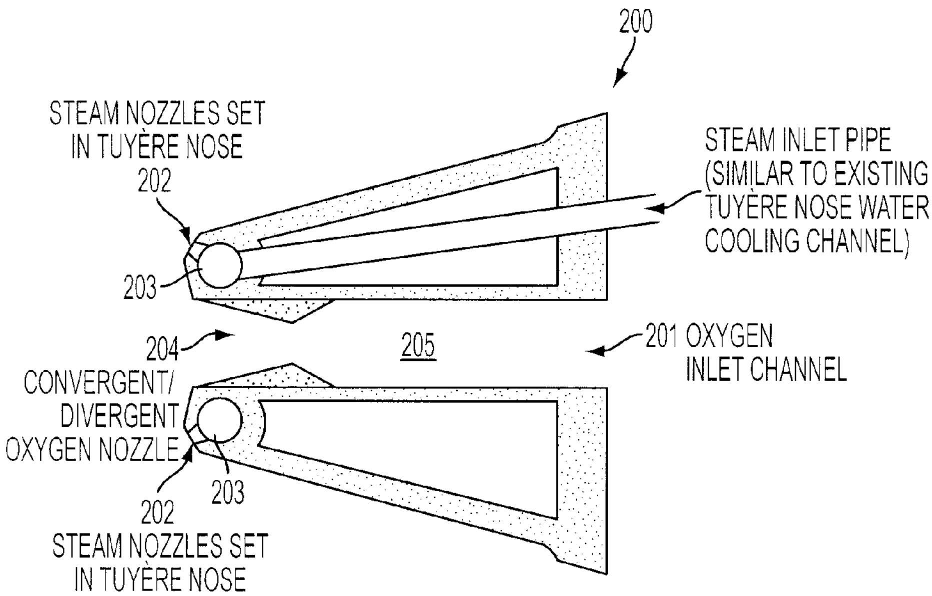

200
STEAM NOZZLES SET
IN TUYÈRE NOSE
202
203
STEAM INLET PIPE
(SIMILAR TO EXISTING
TUYÈRE NOSE WATER
COOLING CHANNEL)
204
205
201 OXYGEN
INLET CHANNEL
CONVERGENT/
DIVERGENT
OXYGEN NOZZLE
203
202
STEAM NOZZLES SET
IN TUYÈRE NOSE

FIG. 3

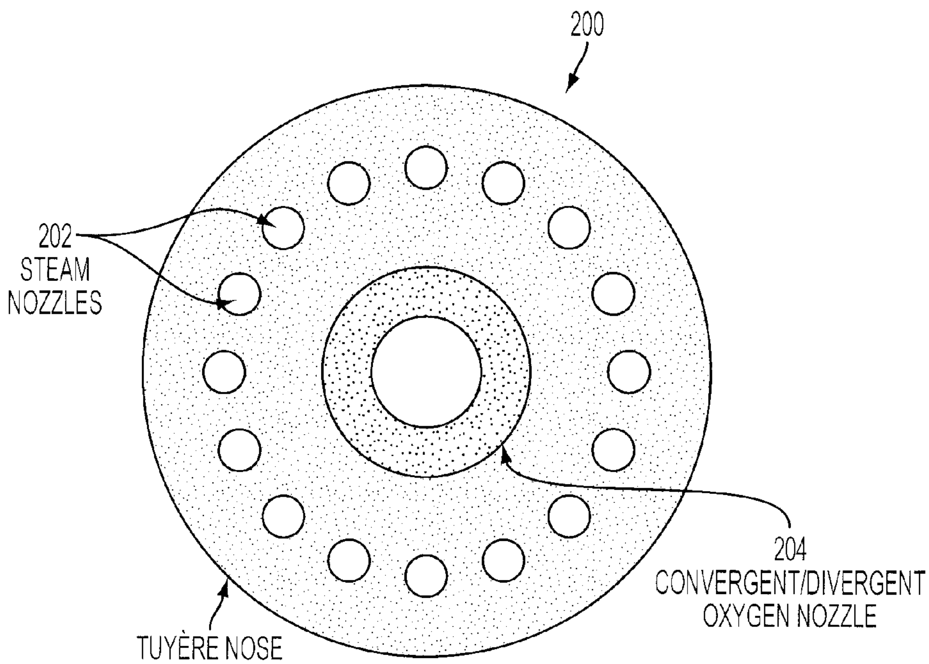

200
202
STEAM
NOZZLES
204
CONVERGENT/DIVERGENT
OXYGEN NOZZLE
TUYÈRE NOSE

FIG. 4

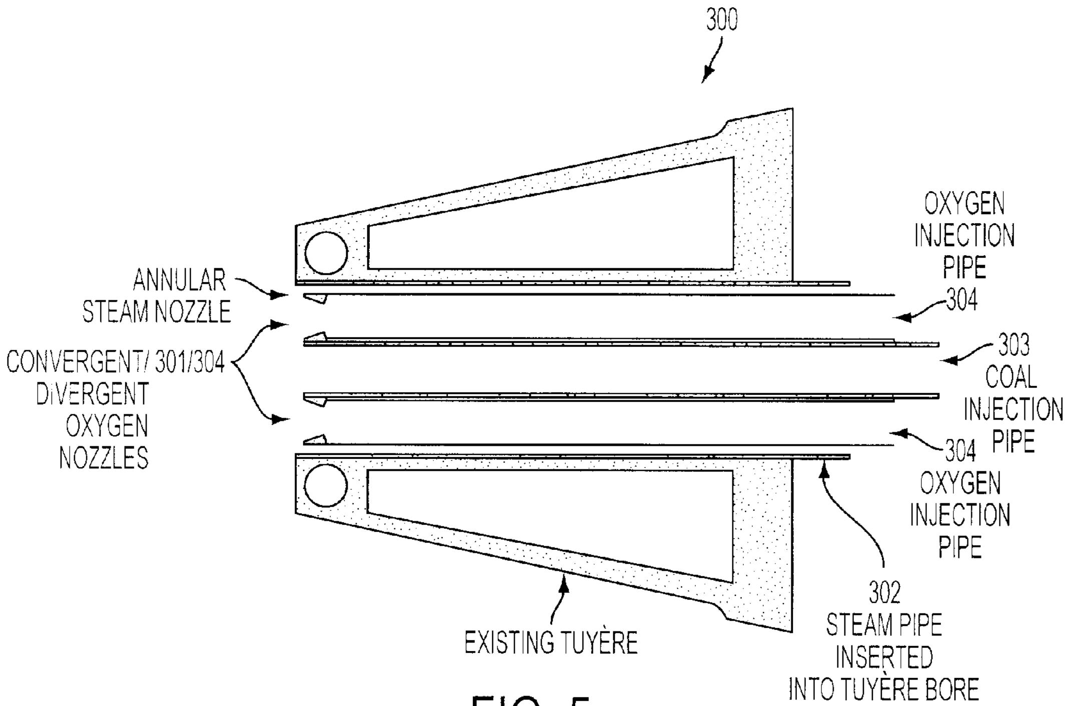

300
OXYGEN
INJECTION
PIPE
304
ANNULAR
STEAM NOZZLE
CONVERGENT/ 301/304
DIVERGENT
OXYGEN
NOZZLES
303
COAL
INJECTION
PIPE
304
OXYGEN
INJECTION
PIPE
EXISTING TUYÈRE
302
STEAM PIPE
INSERTED
INTO TUYÈRE BORE

FIG. 5

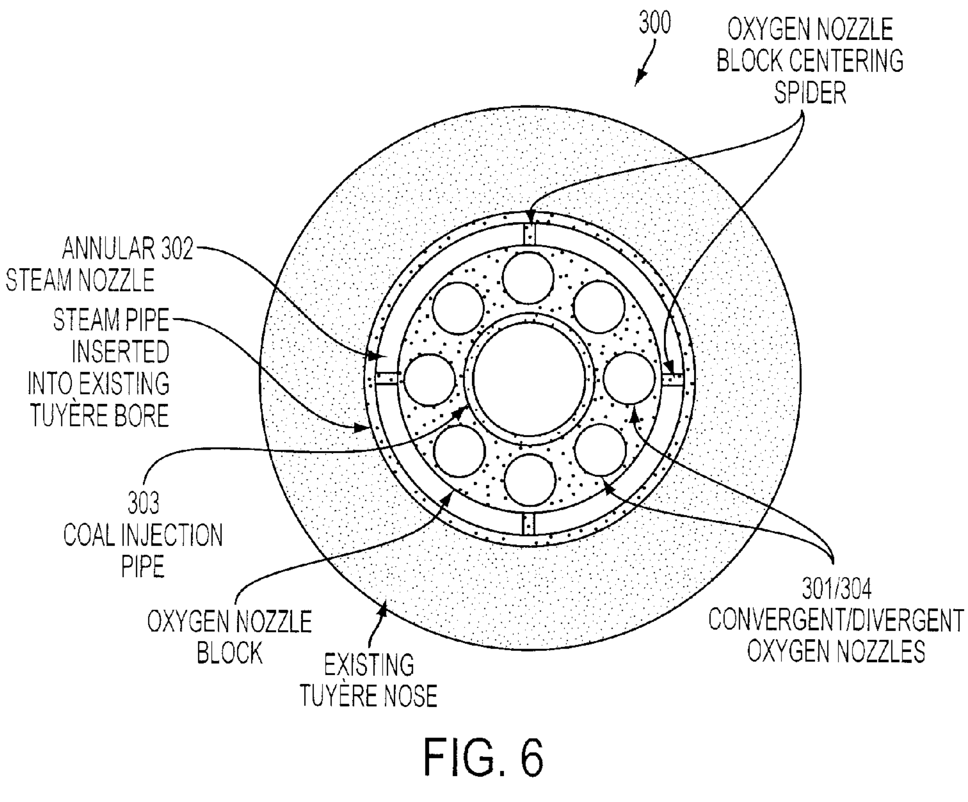

300
OXYGEN NOZZLE
BLOCK CENTERING
SPIDER
ANNULAR 302
STEAM NOZZLE
STEAM PIPE
INSERTED
INTO EXISTING
TUYÈRE BORE
303
COAL INJECTION
PIPE
OXYGEN NOZZLE
BLOCK
EXISTING
TUYÈRE NOSE
301/304
CONVERGENT/DIVERGENT
OXYGEN NOZZLES

FIG. 6

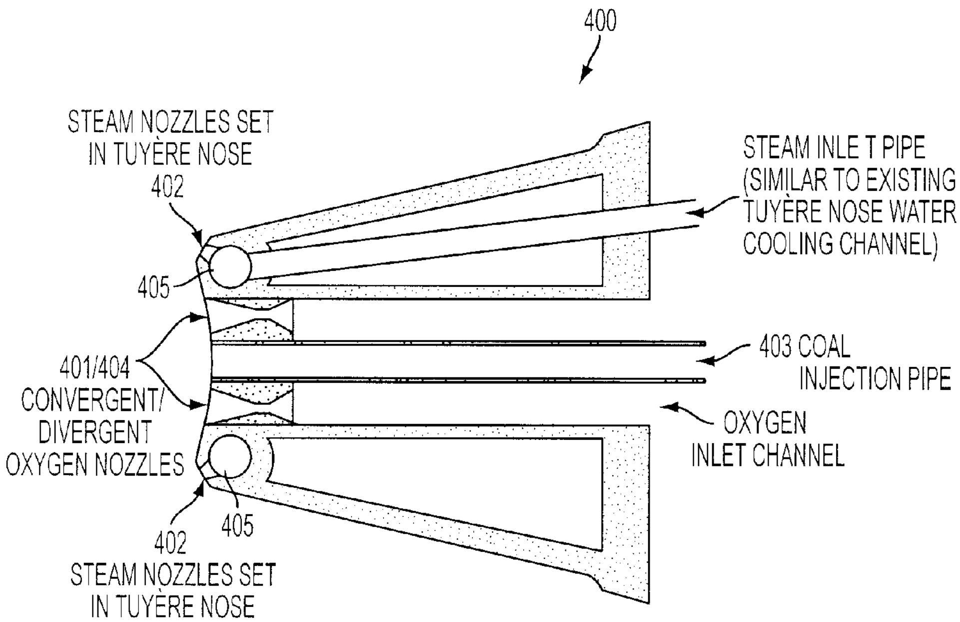

400
STEAM NOZZLES SET
IN TUYÈRE NOSE
402
405
STEAM INLE T PIPE
(SIMILAR TO EXISTING
TUYÈRE NOSE WATER
COOLING CHANNEL)
401/404
CONVERGENT/
DIVERGENT
OXYGEN NOZZLES
403 COAL
INJECTION PIPE
OXYGEN
INLET CHANNEL
405
402
STEAM NOZZLES SET
IN TUYÈRE NOSE

FIG. 7

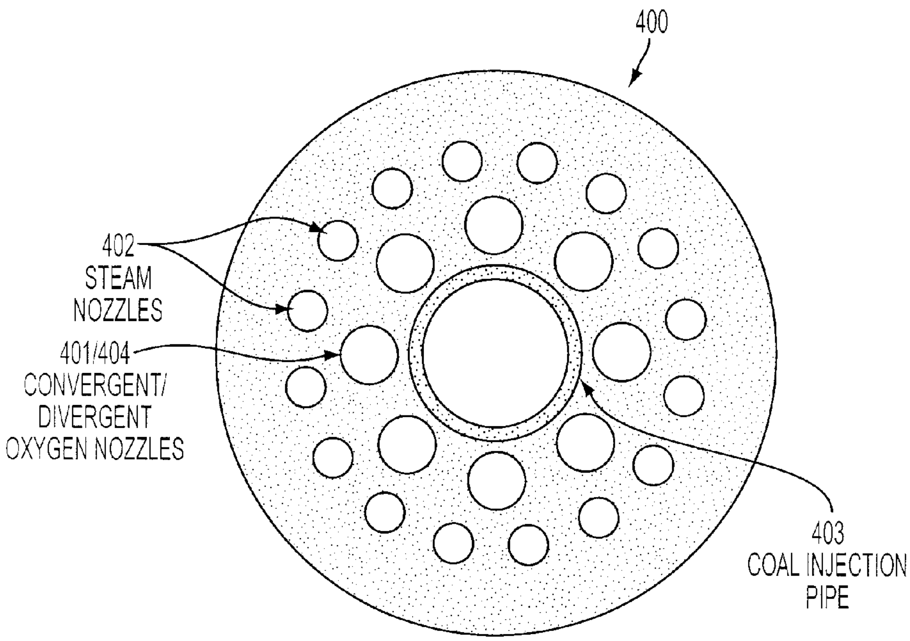

400
402
STEAM
NOZZLES
401/404
CONVERGENT/
DIVERGENT
OXYGEN NOZZLES
403
COAL INJECTION
PIPE

FIG. 8

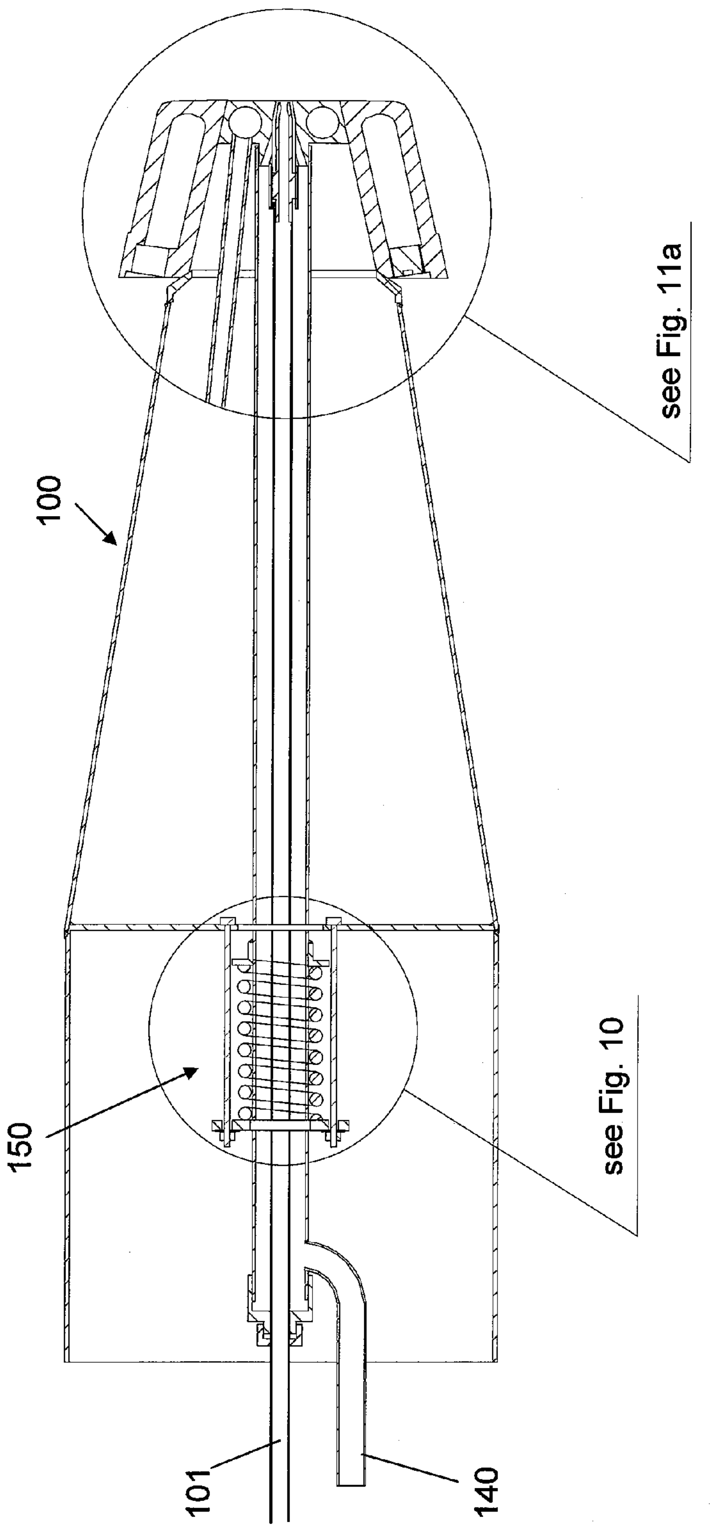


Fig. 9

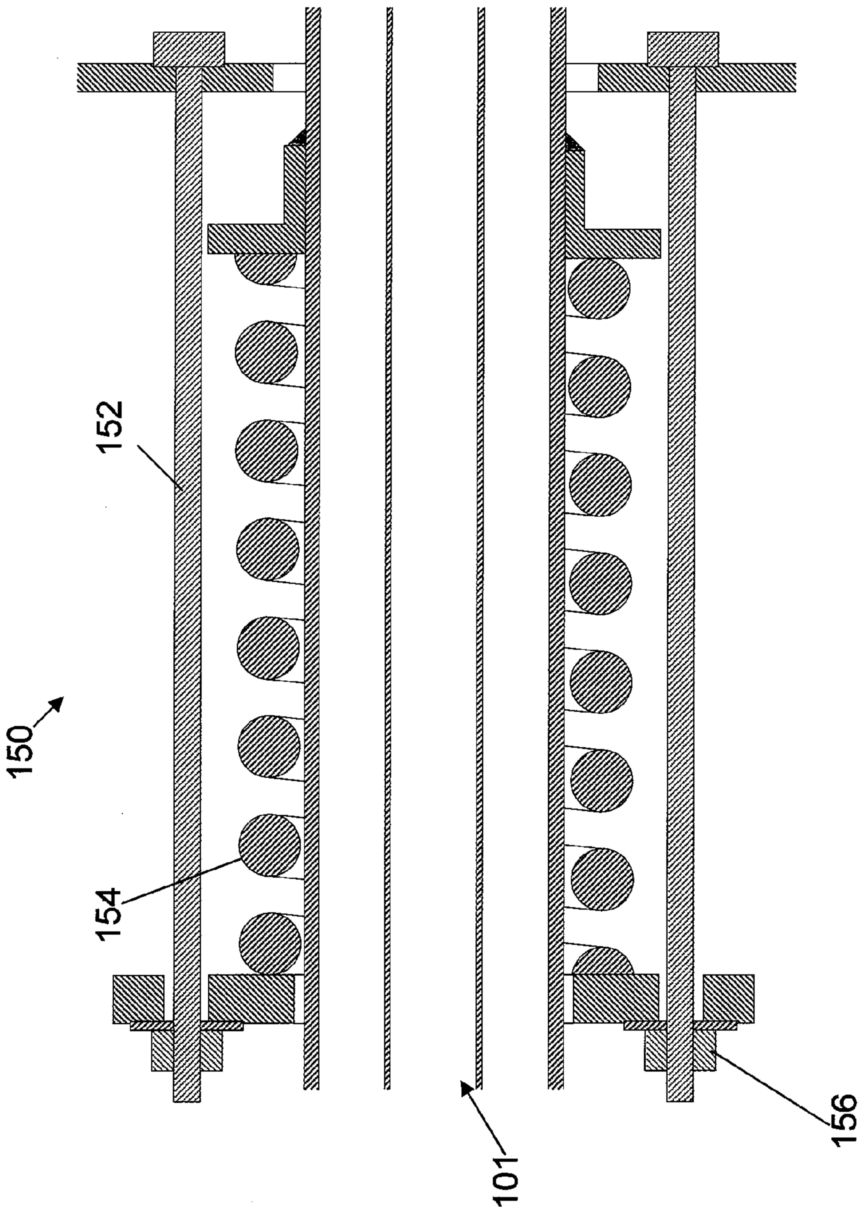


Fig. 10

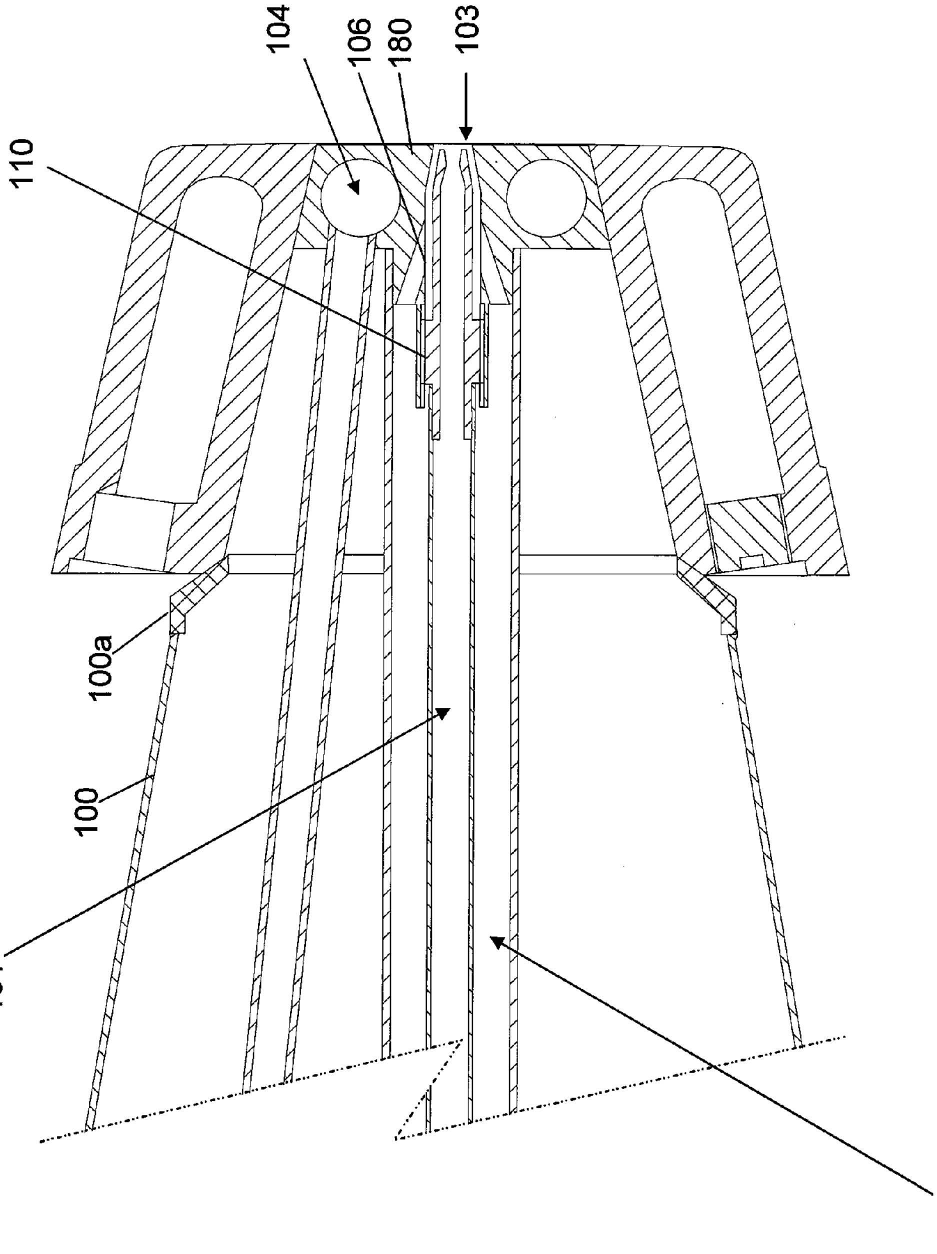


Fig. 11a

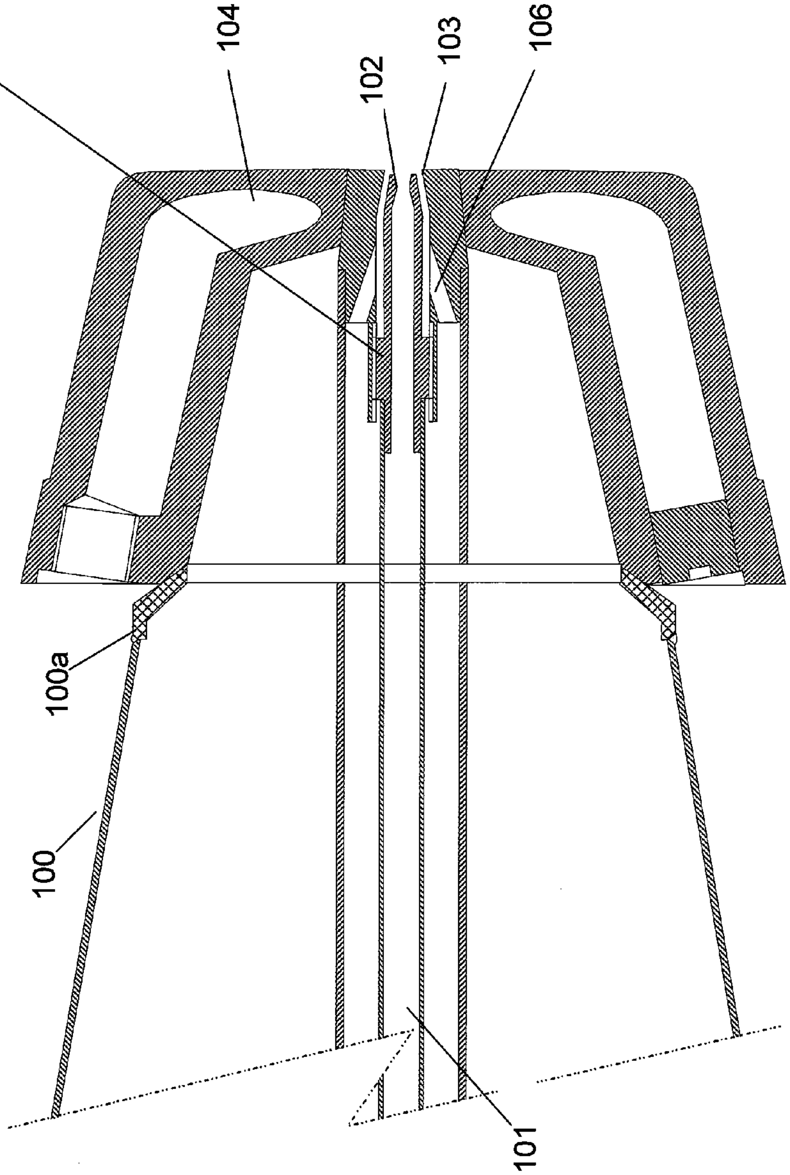


Fig. 11b

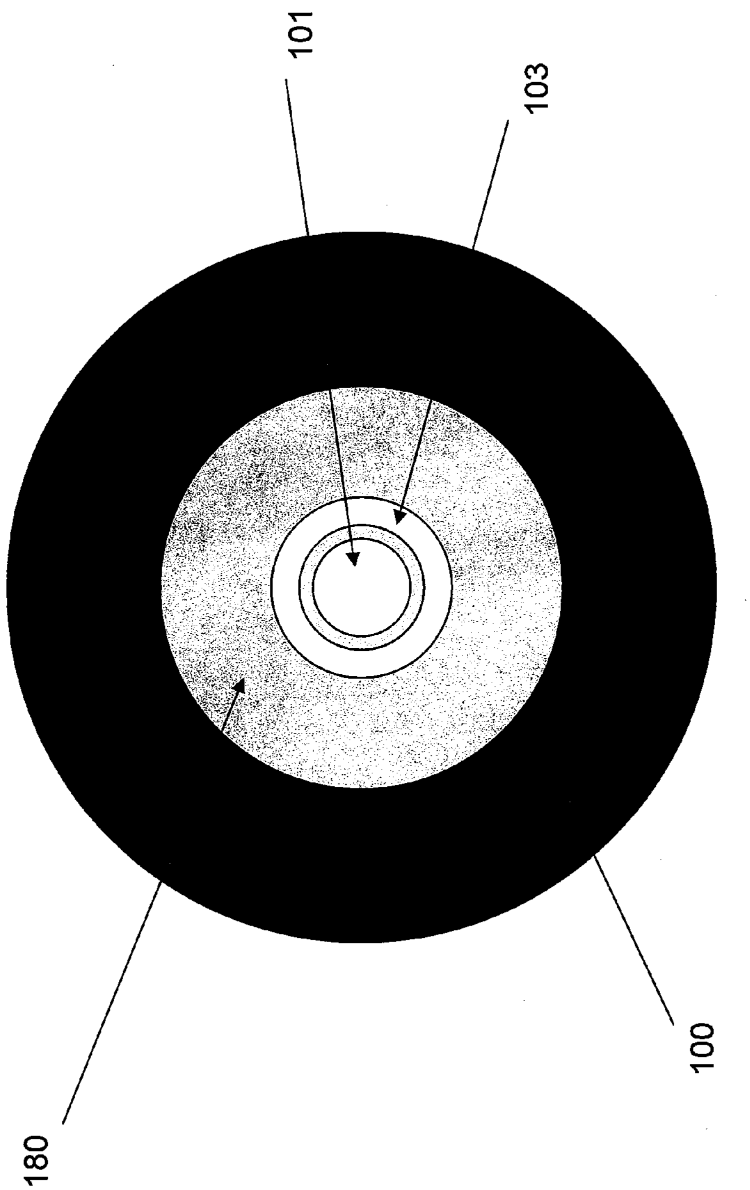


Fig. 11c

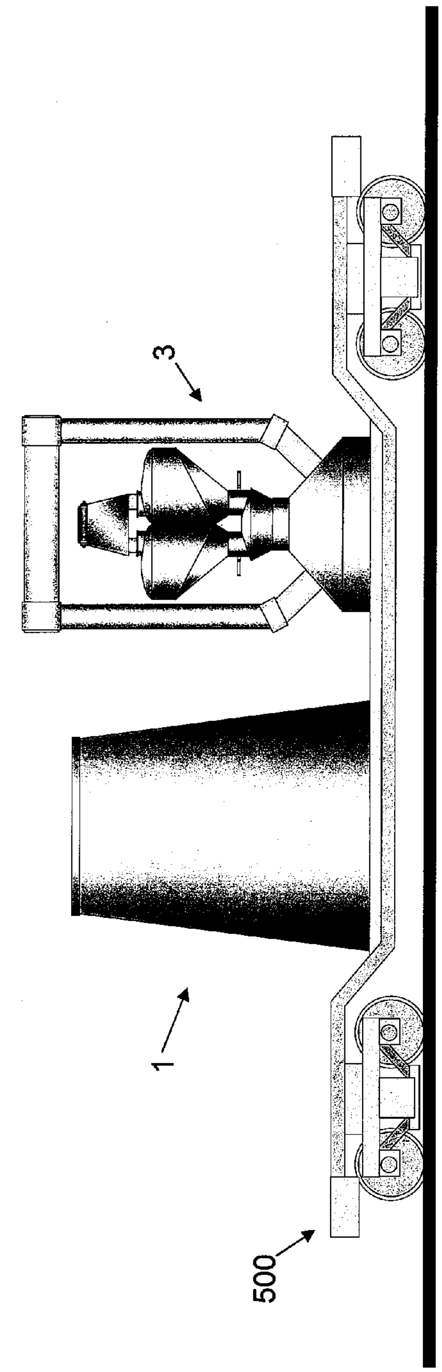


Fig. 12a

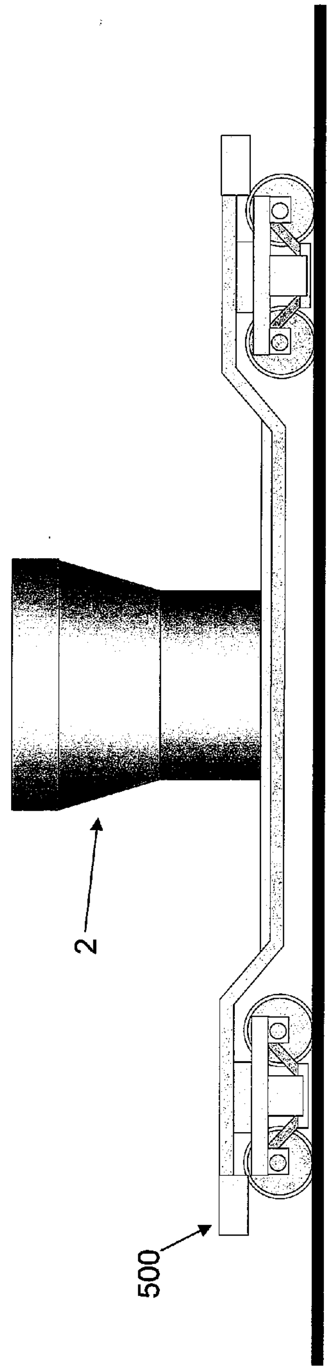


Fig. 12b

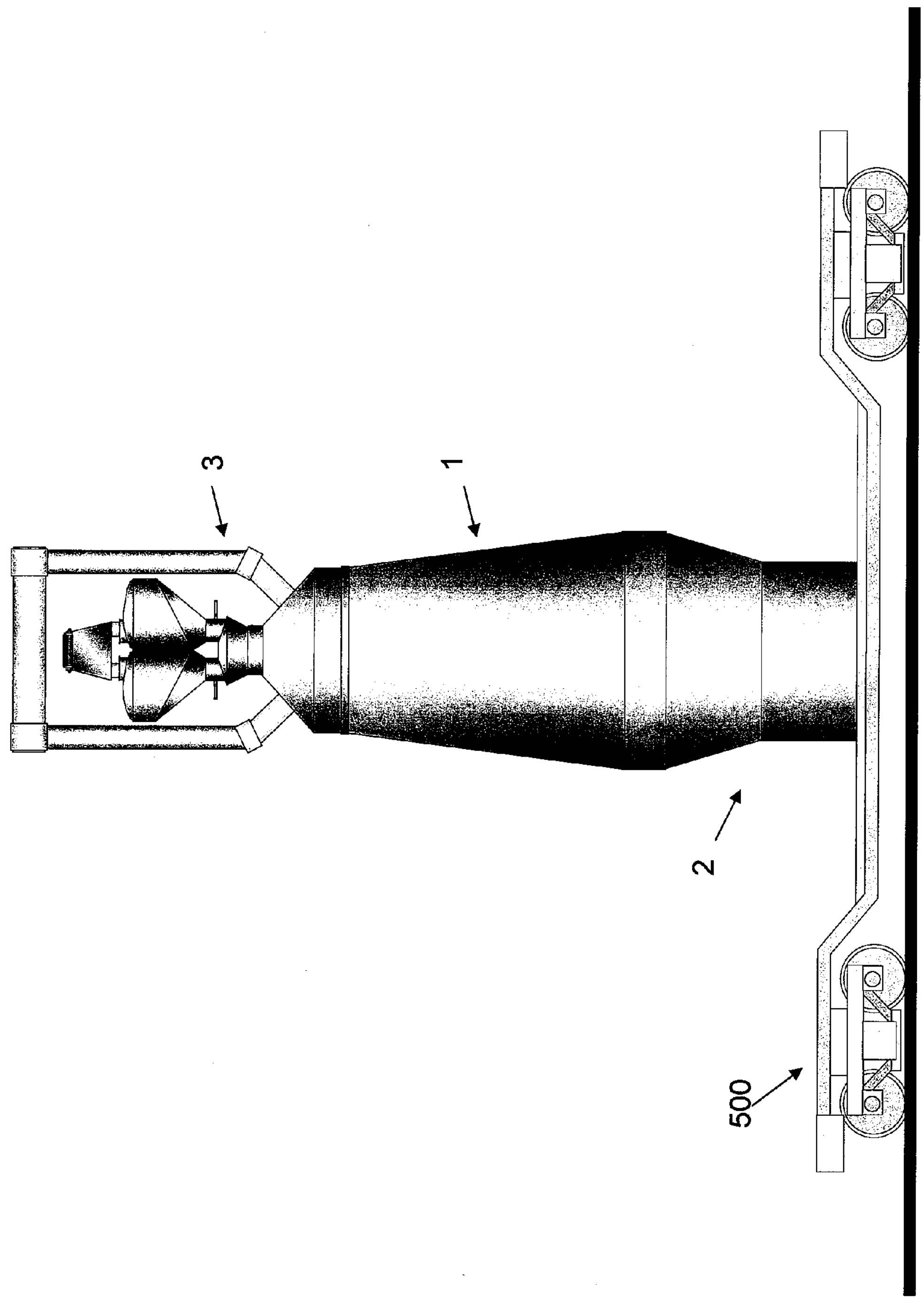


Fig. 12c

TUYERE FOR OXYGEN BLAST FURNACE CONVERTER SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims benefit under 35 U.S.C. §119(e) to Application No. 60/746,085, filed May 1, 2006, the disclosure of which is incorporated by reference.

BACKGROUND

[0002] An oxygen blast converter system (oxygen blast furnace system) is described in U.S. Pat. No. 6,030,430, the disclosure of which is hereby incorporated by reference in its entirety. The converter system has a blast furnace which employs a continuous oxygen jet blast and can be operated to consume, by conversion, a wide range of raw materials including wastes of many kinds, e.g., a wide range of toxic and hazardous wastes, oil shales and sands and other inferior or difficult-to-process raw materials. These materials are converted into fuel gases, molten metal, molten slag, vapors and dusts. Some conversion products are useable as produced, while others can be converted in other production units in the system.

[0003] In U.S. Pat. No. 6,030,430, an injection system for delivering oxygen and other reactants into the converter system includes tuyeres T**1** and T**2**. The tuyere T**2** may be used for injection of a minimal amount of endothermic materials or other injectable materials with the oxygen, and the remaining endothermic materials or other injectable materials injected through tuyere T**1**. Alternatively, the tuyere T**2** may be used for injection of all materials; or the tuyere T**2** may be used for injection of any portion of materials with the oxygen, and remaining materials being injected through tuyere T**1**. A process control computer and auxiliary tuyere inputs and outputs can be employed to regulate temperature-controlled activities taking place in the converter zones and the quality of the outputs. These results can be inputted into the process control computer, which can schedule periodic purges through appropriate tuyere sets, e.g., when a build up of materials occurs.

SUMMARY

[0004] The present invention is directed to a tuyere for use in an oxygen blast furnace/converter system. In one aspect, the tuyere comprises a body and a first conduit extending through a longitudinal center portion of the body. The first conduit has an outboard end external to the furnace and an inboard end extending into the furnace. The first conduit is adapted to receive a medium at the outboard end and discharge the medium at the inboard end through a discharge nozzle inside the furnace. A second conduit is arranged concentrically around the first conduit and is adapted to receive a medium at a first end of the conduit and discharge the medium at a second end of the conduit through a discharge nozzle.

[0005] In another aspect, a tuyere comprises a body, a first conduit extending through a longitudinal center portion of the body. The first conduit is adapted to receive a medium at a first end of the conduit and discharge the medium at a second end of the conduit through a discharge nozzle. A plurality of secondary conduits extends through the tuyere body and these are adapted to receive a medium at a first end of the conduits and discharge the medium at a second end of the conduits through a plurality of radially distributed discharge nozzles.

[0006] In yet another aspect, a tuyere comprises a body and a first conduit extending through the body. The first conduit is adapted to receive a medium at a first end of the conduit and discharge the medium at a second end of the conduit through at least one discharge nozzle. A second conduit is arranged concentrically around the first conduit and is adapted to receive a medium at a first end of the conduit and discharge the medium at a second end of the conduit through at least one discharge nozzle. A third conduit extends through the tuyere body and is adapted to receive a medium at a first end of the conduit and discharge the medium at a second end of the conduit through at least one discharge nozzle.

[0007] In another aspect, a portable oxygen blast furnace system includes an oxygen blast furnace secured to a railcar. The furnace can be partially dissembled, as needed, and transported by rail along with an oxygen separation unit. The portable oxygen blast furnace system is particularly advantageous for use in applications having a temporary need for the system, e.g., gasifying and converting debris at sites afflicted by a hurricane or other natural or manmade disasters.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will now be described in more detail with reference to preferred embodiments of the invention, given only by way of example, and illustrated in the accompanying drawings in which:

[0009] FIG. **1** is a cross sectional side elevation view of a two-component injection tuyere in accordance with one embodiment of the invention;

[0010] FIG. **2** is an end elevation on the tip of the tuyere of FIG. **1**;

[0011] FIG. **3** is a cross sectional side elevation view of a two-component injection tuyere having a divergent stream arrangement in accordance with another embodiment of the invention;

[0012] FIG. **4** is an end elevation on the tip of the tuyere of FIG. **3**;

[0013] FIG. **5** is a cross sectional side elevation view of a three-component injection tuyere in accordance with another embodiment of the invention;

[0014] FIG. **6** is an end elevation on the tip of the tuyere of FIG. **5**;

[0015] FIG. **7** is a cross sectional side elevation view of a three-component injection tuyere having a divergent stream arrangement in accordance with another embodiment of the invention;

[0016] FIG. **8** is an end elevation on the tip of the tuyere of FIG. **7**;

[0017] FIG. **9** is a schematic illustration of a blast pipe, tuyere, and nozzle arrangement for a retrofit design that allows the use of the aforementioned nozzle designs without modifying an existing tuyere design and instead embodying these nozzles designs into a metal plug that fits in to the existing tuyere; this is a typical example of the concept but the engineering details of the ultimate version will depend on the specific design details of the furnace and blast pipe assembly to which it is applied;

[0018] FIG. **10** is an exploded, schematic illustration of a securing and tensioning arrangement for a nozzle assembly; once again this is a typical conceptual example but the engineering details of the ultimate version will depend on the specific design details of the furnace and blast pipe assembly to which it is applied;

[0019] FIG. **11***a* is a schematic illustration of a tuyere and nozzle assembly using the retrofit design that utilizes a metal plug for embodying the nozzle design and requires no modification to the existing tuyere, simply fitting into the tuyere bore and being held in place by the securing and tensioning arrangement shown in FIG. **10**;

[0020] FIG. **11***b* is a schematic illustration of a retrofit design that requires only slight modification to an existing tuyere design to integrate the cooling into the existing tuyere cooling system instead of having an independent plug cooling system;

[0021] FIG. **11***c* is an end elevation on the tip of the tuyere of FIG. **11***a;*

[0022] FIGS. **12***a*-**12***c* illustrate a portable oxygen blast furnace system which can be partially disassembled and transported by a railcar.

DETAILED DESCRIPTION

[0023] The tuyeres of the present invention are useful for injecting materials into oxygen blast converter systems (oxygen blast furnace systems), such as the oxygen blast converter system described in U.S. Pat. No. 6,030,430. The tuyere configurations may vary in shape, distribution pattern, velocities, flow momentum control, cooling, amount of material injected, and other properties. The tuyere configurations described and illustrated herein are only given by way of example, and it should be recognized that the configuration of tuyeres, blast pipes, tensioning arrangements, and other structures can vary widely from the examples described herein without departing from the spirit or scope of the invention.

[0024] In one embodiment, an oxygen blast tuyere can have a multi-barrel design with discrete or mixed material flowing through different concentric ringed barrels. The central barrel may have oxygen or a mixed material flow of oxygen, steam, carbon dioxide, or other injectable materials with oxygen compatibility. The outer concentric barrels may be used to inject steam or other injected materials (e.g., pulverized coal, ore, limestone, etc.). The steam or other endothermic materials may be injected in a manner that satisfies the cooling needs of the tuyere and moderation of the adiabatic flame temperature from the oxygen in the central flow to protect the tuyere and the walls of the furnace from the heat from the oxygen flame. Injectable materials may facilitate other conditions inside the furnace, such as tuyere raceway creation and adequate heat or reducing gases. The central barrel may alternatively contain a wide variety of discrete or mixed injectable materials (e.g., pulverized coal, ore, limestone, steam, etc.), and the outer barrel(s) may contain oxygen with or without oxygen-compatible injectable materials, and further outer barrels may contain endothermic materials (steam, carbon dioxide, etc.) to satisfy the above described needs of the tuyere cooling and other described system needs.

[0025] In another embodiment, a tuyere has a single central barrel with additional radially distributed nozzles around the central barrel on the tuyere head that inject other injectable materials such as steam, carbon dioxide, etc. These additional nozzles may be on the front of the tuyere nose and/or distributed radially and longitudinally along the taper of the tuyere exposed in the furnace. The central tuyere barrel may have oxygen or mixed material flow of oxygen, steam, carbon dioxide, or other oxygen compatible injectable materials. The radially distributed nozzles may be used to inject steam or other injectable materials in a manner to satisfy the cooling needs of the tuyere and moderate the adiabatic flame temperature from the oxygen in the central flow to protect the tuyere and the walls of the furnace from the heat, as well as to facilitate other conditions inside the furnace such as overall injectant plume geometry for proper operation. The central barrel may alternatively contain a wide variety of discrete or mixed injectable materials (e.g., pulverized coal, ore, limestone, steam, etc.), and the outer radial nozzles may contain oxygen with or without oxygen compatible injectable materials, and further outer nozzles or barrels of endothermic materials (steam, carbon dioxide, etc.).

[0026] Any of the various nozzles described herein may be either formed integrally with the tuyere and/or the conduit extending through the tuyere or as discrete structures suitably attached to the tuyere and/or conduit. The nozzles may have various geometries, including those having a uniform cross-section or a non-uniform cross-section. Any of the various nozzles described herein can be, for example, converging, diverging, converging/diverging, or diverging/ converging nozzles. The cross-section, whether uniform or non-uniform, may have various geometries, e.g., generally circular or defined by concentric circles or portions thereof. Alternatively, the cross-section may be defined by straight lines, e.g., rectangular, or may be defined by a combination of curved and straight lines, e.g., crescent moon shaped. The dimensions and geometries of the nozzles can be selected to deliver the respective mediums at appropriate conditions, such as pressure and velocity, to the blast furnace and to achieve desired overall injectant plume geometry.

[0027] The flow momentum requirements for the flow from the tuyere to provide a force or thrust continually to move material within the blast furnace to create an adequate tuyere raceway may be controlled through both velocity and mass flow of the materials flowing through the tuyere. Oxygen compatible injectable materials like steam and carbon dioxide may be mixed with the oxygen in the central flow or outer barrel or nozzle flows to provide more mass and thus a greater momentum force or thrust vector when that flow impacts the material in the furnace. Alternatively, a wide variety of injectable materials (e.g., pulverized coal, ore, limestone, steam, etc.) may be injected through either the central barrel or other barrels or nozzles at a velocity to provide additional flow momentum force on the burden materials in the furnace. Another means of increasing the flow momentum or force/thrust is through controlling the velocity of the flow(s). Increased pressure of the oxygen and injectable materials and the use of accelerating nozzles, such as convergent-divergent nozzles, may be used to increase the velocity of the flows, so that the mass that is within the flows exerts more force as it impacts and is decelerated by the material in the furnace tuyere raceway. These principles may be applied to the aforementioned barrel and nozzle arrangement tuyere embodiments.

[0028] Steam or hot water injection through the body of the tuyere in any of the aforementioned embodiments may provide both inner tuyere cooling, as well as provide heating for the steam or water, e.g., just prior to being injected into the furnace, thus providing a synergistic effect of heating the steam or water while cooling the tuyere.

[0029] The injection of steam or water or other injectable material into the furnace through the tuyere may be performed at different angles and rates depending upon the position of the injection on the tuyere in order to provide an adequate heat insulating and chemically endothermic barrier layer both above and below the tuyere midline as a protection from radiant and convective heat transfer from the oxygen flame. The prevalent upward flow in the furnace may affect the penetration, size, heat distribution, reactions, or other characteristics of the raceway resulting from the injection of oxygen and the insulating layer above or below the tuyere mid-line provided by the steam or other injectants, which may require different distributing patterns, angles, pressure, or flow rates above or below the tuyere mid-line and laterally to provide an appropriately distributed insulating layer.

[0030] It may be desirable to create a rotating flow, using the trajectory and rate of injection of steam or water or other injectable materials in order to provide a more even heat distribution within the layer between the oxygen flame and the walls of the furnace and to promote more intimate contact between the injected materials and the deadman carbon in order to drive conversions like $C+H_2O=CO+H_2$. It may also be desirable to inject carbon or carbonaceous fuels (e.g., petroleum coke, coal or coke fines) to assist in the conversion of other injected materials like H_2O liquid or vapor, if it is found that these injected materials are not being converted to desirable species like O, CO, H_2, etc due to insufficient contact between the deadman coke and the injectant flows before the raceway gases ascend. This situation is largely mitigated when utilizing the T**1** tuyere set to inject steam or water or other injectable materials like carbon dioxide, as they ascend through the region at the base of the deadman thus mixing with and having greater exposure to the deadman carbon to facilitate desired reactions before ascending through the T**2** tuyere region.

[0031] Injection at the T**1** tuyere to help protect the lining below the tuyere level and provide dissociation of the steam or other injectable materials at a lower level in the furnace may provide a more evenly distributed insulating layer at the furnace wall and allow more heating of CO and H as it approaches and passes the T**2** tuyeres for better heat transfer per volume of gas. However, the use of the T**1** tuyere requires actual physical modifications to the body of the furnace, which may be undesirable from a production downtime perspective, thus there is an advantage of being able to use a tuyere design at the example T**2** tuyere that can support injection of the necessary materials.

[0032] The design of the tuyeres at T**2** may be designed to fit within an existing blast furnace's tuyere cooler openings, so that tuyeres may be replaced with new oxygen blast type tuyeres without any major replacement of furnace hardware or structural modification. This flexibility allows for utilizing oxygen blast type tuyeres with other blast injectable materials without significant interruption of production to modify the actual furnace body and it also allows for trials and phasing in of the technology by replacing tuyeres incrementally and reversibly.

[0033] FIGS. **1** and **2** illustrate an example embodiment of a double barrel oxygen blast tuyere identified as the two component injection tuyere insert arrangement **100**. This embodiment utilizes a multi-barrel approach with oxygen flowing through the central barrel **101** at accelerated speeds from a convergent/divergent nozzle **102** and steam flowing through the outer barrel **103** at high pressure and angled for distributing the steam outward and around the central oxygen flow. The steam flow provides cooling to the tuyere tip and provides a wall of endothermic protection to the tuyere and the furnace wall.

[0034] This embodiment may be used to inject the oxygen blast and the required steam, water, or carbon dioxide for the process in discrete or mixed flows while avoiding the need for an additional set of lower tuyeres, for example the tuyeres T**1** used in U.S. Pat. No. 6,030,430 as described above.

[0035] In the embodiment of FIGS. **1-2**, an oxygen blast tuyere can be fabricated by modifying an existing air blast tuyere, for example, by inserting an assembly into the existing tuyere bore. Alternatively, tuyeres of this design may be cast with the features integral with the tuyere body, e.g., cast from copper or other suitable material. Either of these design variants can be implemented with minimal production interruption and allows for trials, phasing, and reversibility of the oxygen blast tuyere.

[0036] FIGS. **3** and **4** illustrate an embodiment of an oxygen blast tuyere with a central barrel **201** and radially distributed nozzles **202** identified as the two component injection tuyere with divergent steam arrangement **200**. This embodiment can incorporate the previously described radially distributed injection nozzles **202** approach, where the steam flows through the tuyere nose cooling channel **203** to provide cooling of the tuyere nose and gain additional heating of the steam before injecting it into the furnace. A convergent-divergent nozzle **204** can be provided for accelerating the oxygen flow in the central barrel **205** for achieving proper flow momentum force to assist in creating a tuyere raceway.

[0037] This embodiment may be used to inject the oxygen blast and the required steam, water, or carbon dioxide for the process in discrete or mixed flows while avoiding the need for an additional set of lower tuyeres, for example the tuyeres T**1** used in U.S. Pat. No. 6,030,430 as described above.

[0038] In the embodiment of FIGS. **3-4**, an oxygen blast tuyere can be fabricated by only slightly modifying an existing air blast tuyere, for example by creating injection nozzles **202** in the nose of the tuyere down into the nose cooling channel **203** and using steam in the nose cooling channel **203**. A convergent-divergent nozzle **204** can be inserted into the nose of the tuyere. Alternatively, new tuyeres of this design may be cast with these features. This design can be implemented with minimal production interruption and allows for trials, phasing, and reversibility of the oxygen blast tuyere.

[0039] FIGS. **5** and **6** illustrate another embodiment in which an oxygen blast tuyere incorporates a combination of radial nozzles **301** and an outer barrel **302**, e.g., so that other injectable materials may be injected in with the blast. This tuyere design is identified as the three component injection tuyere insert arrangement **300**. Other injectable solid materials (pulverized coal, ore, limestone, etc.) can be injected into the furnace with the blast by using the central barrel **303** for injecting these discrete or mixed materials. Radial nozzles **301** allow for oxygen to be injected around these materials, and an outer barrel **302** for steam injection around the oxygen.

[0040] The usage of the central barrel **303** for the solid injectable materials is preferable in order to minimize wearing of parts in the tuyere and its feeding apparatus due to the abrasiveness of the materials, as well as helping in avoiding blockages in the tuyere and its feeding apparatus. The solid injectable material may be pneumatically conveyed to and through the tuyere using carbon dioxide or cleaned and compressed furnace top gas instead of air in order to avoid introducing nitrogen into the system. Carbon dioxide may be preferable to nitrogen because it may be reduced to carbon monoxide, which is a desired species in the converter system, and the furnace top gas, which will also be nitrogen free, has already been through this process.

[0041] Since the momentum force from the oxygen flow from the nozzles **301** will still be important in the creation of the tuyere raceway in the furnace, flow acceleration using convergent-divergent nozzles **304** may be utilized. When a reduction in the total oxygen volume is required for process purposes during operation, the flow rate through some of the nozzles **301** may be interrupted while leaving the rest of the nozzles **301** at full flow rate, so that adequate momentum force is still exerted on the burden in the furnace to create an adequate tuyere raceway. Maintaining full flow rate in a sub-set of oxygen nozzles **30** should allow them to continue to operate at their optimal convergent-divergent nozzle **304** design conditions.

[0042] This embodiment may be used to inject the oxygen blast and the required steam, water, carbon dioxide, or other injectable materials for the process while avoiding the need for an additional set of lower tuyeres, for example the tuyeres T**1** used in U.S. Pat. No. 6,030,430 as described above. The tuyere can be fabricated by modifying an existing air blast tuyere, e.g., by inserting an assembly into the existing tuyere bore. Alternatively, the tuyere may be cast with these features. This design allows for minimal production interruption and allows for trials, phasing, and reversibility of the installation of the oxygen blast tuyere.

[0043] FIGS. **7** and **8** illustrate an alternative embodiment of an oxygen blast tuyere that incorporates multiple sets of radial nozzles for oxygen injection **401** and steam injection **402** with a central barrel **403** for injecting solid injectable materials (pulverized coal, ore, limestone, etc.) into the furnace. This embodiment is identified as the three component injection tuyere with divergent steam arrangement **400**. This embodiment allows for the injection of other injectable solid materials (pulverized coal, ore, limestone, etc.) into the furnace with the blast by using the central barrel **403** for injecting these discrete or mixed materials, and having radial nozzles **401** for oxygen to be injected around these materials, and an outer set of radial nozzles **402** for steam injection around the oxygen. The radial oxygen and steam nozzles may also be given a tangential directional component to impart a rotational moment to the injectant plume if desired.

[0044] The radial steam nozzles can tap into the nose cooling channel **405** to provide cooling of the tuyere nose and gain additional heating of the steam before injecting it into the furnace. A convergent-divergent nozzle profile **404** may be provided for accelerating the oxygen flow in the radial oxygen nozzles **401** for achieving proper flow momentum force to assist in creating a tuyere raceway. The oxygen and steam nozzles may also be given a tangential directional component to impart a rotational moment to the injectant plume if desired.

[0045] The usage of the central barrel **403** for the solid injectable materials in pulverized form may be preferable in order to minimize wearing of parts in the tuyere and its feeding apparatus due to the abrasiveness of the materials, as well as helping to avoid blockage of the formation of obstructions in the tuyere and its feeding apparatus. The solid injectable material may be pneumatically conveyed to and through the tuyere using carbon dioxide or cleaned and compressed furnace top gas rather than air in order to avoid introducing nitrogen into the system. Carbon dioxide is generally preferable to nitrogen because it may be reduced to carbon monoxide, which is a desired species in the converter system, and the furnace top gas, which will also be nitrogen-free, has already been through this process.

[0046] Since the momentum force from the oxygen flow from the nozzles **401** will still be important in the creation of the tuyere raceway in the furnace, flow acceleration using convergent-divergent nozzles **404** may be utilized. When a reduction in the total oxygen volume is required for process purposes during operation, the flow rate through some of the nozzles **301** may be interrupted while leaving the rest of the nozzles **301** at full flow rate, so that adequate momentum force is still exerted on the burden in the furnace to create an adequate tuyere raceway. Maintaining full flow rate in a sub-set of oxygen nozzles **401** should allow them to continue to operate at their optimal convergent-divergent nozzle **404** design conditions.

[0047] This embodiment may be used to inject the oxygen blast and the required steam, water, carbon dioxide, or other injectable materials for the process while avoiding the need for an additional set of lower tuyeres, for example the tuyeres T**1** used in U.S. Pat. No. 6,030,430 as described above.

[0048] In this embodiment, an oxygen blast tuyere can be fabricated by modifying an existing air blast tuyere, e.g., by creating injection nozzles **402** in the nose of the tuyere down into the nose cooling channel **405** and using steam in the nose cooling channel **405**. A radial convergent-divergent oxygen nozzles **401** and central barrel **403** can be inserted into the existing tuyere shaft. Alternatively, tuyeres of this design may be cast with these features. This design allows for minimal production interruption and allows for trials, phasing, and reversibility of the installation of the oxygen blast tuyere.

[0049] As shown, for example, in FIGS. **11***a* and **11***b*, a tuyere can be provided with an adjustable steam opening **103**. The steam opening **103** can be adjusted by moving an inner nozzle inwardly or outwardly to modify the size of the steam opening **103** and allow fine tuning of steam flow. Adjustability of the steam opening **103** can be accomplished, for example, by providing fine threads **110** along the inner nozzle as shown in FIGS. **11***a* and **11***b*.

[0050] In some instances an existing tuyere can be retrofitted without requiring modification of existing structure such as blowpipe shell geometry, attachment, and mating mechanisms. Such retrofitting can be accomplished, for example, by inserting a metal plug **180** that fits inside the tuyere bore, as shown in FIGS. **11***a* and **11***c* and described more fully below.

[0051] FIGS. **9-11** illustrate an example of a retrofitted tuyere **100** that is equipped with tuyere/blast pipe tensioning brackets and a nozzle securing and tensioning arrangement **150**. Referring to FIG. **10**, the nozzle securing and tensioning arrangement **150** includes a coil spring **154** and support elements **152** and **156**. FIGS. **11***a* and **11***b* shows the details of the tuyere stock cone fabrication **100** and nose casting **100***a*. The tuyere may be a replacement of the existing air blast tuyere with a new casting with an extended water cooled nose section, as shown in FIG. **11***b*, or could be implemented by insertion of a tapered cylindrical copper plug **180** into an existing air blast tuyere, as shown in FIGS. **9** and **11***a* without requiring any modification to the existing tuyere. The tuyere nozzle insert portion has four channels **106** (only two visible in FIGS. **11***a* and **11***b*) that converge from a conduit surrounding the oxygen inlet pipe **101** toward the steam nozzle **103**.

[0052] The plug **180** is held in place by a tensioning force at the back of the shaft that connects to it and forces it up against the inner walls of the existing tuyere **100**. Existing blow pipe shells and their blast furnace attachment and tuyere mating mechanisms can be used without modification. The back of the blow pipe can be cut off and the internal opening inside the blow pipe can be modified as shown in FIG. **9** and **11***a* and **11***b*, as needed, to mount the retrofit shaft and provide the proper tensioning of the retrofit shaft and plug, as well as piping for oxygen and steam.

[0053] Retrofitting can be accomplished by inserting an assembly into the existing tuyere **100** that is configured with any of the previously described conduit arrangements (e.g., one having an oxygen inlet **101** pipe and a concentric outer conduit, as shown), and removing the outboard fittings and internal refractories of an existing blast pipe. The existing blast pipe cone fabrication **100** and nose casting **100***a* can remain in place along with the tuyere and its cooling channels **104**. The tensioning arrangement **150** and tuyere/blast pipe tensioning brackets can be used to secure the conduit assembly, as shown in FIGS. **9** and **10**.

[0054] In another aspect, a portable oxygen blast furnace system includes an oxygen blast furnace secured to a railcar. The furnace can be partially dissembled, as needed, and transported by rail along with an oxygen converter unit, e.g., placed on a separate railcar. The portable blast furnace system is particularly advantageous for use in applications having a temporary need for blast furnaces, e.g., gasifying and converting waste material at sites afflicted by a hurricane or other natural or manmade disasters.

[0055] With reference to FIG. **12***b*, a portable blast furnace can be constructed by securing the base portion **1** of a blast furnace to a railcar **500**. The dimensions of blast furnaces are typically too large to permit fully assembled units to be transported by rail. As a result, one or more upper sections **2** and **3** of the furnace are removed to avoid exceeding railroad height restrictions. For example, the uppermost 40 feet of a furnace having a total height of 60 feet can be removed in sections. The removed upper section(s) **2** and **3** can be transported on another railcar, as shown in FIG. **12***a*. Other support equipment like an oxygen separation unit, material conveyors, gas cleaning systems, steam generation systems, etc. can also be transported as pre-fabricated subassemblies on separate railcars to provide a complete transportable system, requiring minimal on site construction, or they may be more permanently pre-installed.

[0056] When the portable blast furnace arrives at its destination, the removed upper section(s) **2** and **3** can be reinstalled onto the base portion **1**, as shown in FIG. **12***c*. The unit can remain on the railcar **500** and can be secured to a suitable pre-installed foundation such as pilings. Refractories may be installed inside the unit once it arrives at its destination.

[0057] When the portable blast furnace is no longer needed at a particular destination, it can be dissembled by removing the refractories and the upper section. The removed upper section and oxygen separation unit and other ancillary equipment can be placed on separate railcars, and the temporary foundation removed. The unit can then be transported by rail to a new location and reinstalled in same manner as previously described.

[0058] While particular embodiments of the present invention have been described and illustrated, it should be understood that the invention is not limited thereto since modifications may be made by persons skilled in the art. The present application contemplates any and all modifications that fall within the spirit and scope of the underlying invention disclosed and claimed herein.

What is claimed is:

1. A tuyere for use in an oxygen blast furnace system comprising a body; a first conduit extending through a longitudinal center portion of the body, wherein the first conduit has an outboard end external to the furnace and an inboard end extending into the furnace, wherein the first conduit is adapted to receive a first medium at the outboard end and discharge the first medium at the inboard end through a first discharge nozzle inside the furnace; a second conduit arranged concentrically around the first conduit, wherein the second conduit is adapted to receive a second medium at a first end of the second conduit and discharge the second medium at a second end of the second conduit through a second discharge nozzle.

2. The tuyere of claim 1 wherein the first discharge nozzle is a convergent/divergent nozzle or a convergent nozzle.

3. The tuyere of claim 1 wherein the second discharge nozzle is a convergent/ divergent nozzle or a convergent nozzle, at a diverting angle of some degree from the direction of the flow from a central shaft.

4. A tuyere for use in an oxygen blast furnace system comprising a body; a first conduit extending through a longitudinal center portion of the body, wherein the first conduit has an outboard end external to the furnace and an inboard end extending into the furnace, wherein the first conduit is adapted to receive a first medium at the outboard end and discharge the first medium at the inboard end through a first discharge nozzle inside the furnace; a plurality of secondary conduits extending through the tuyere body, wherein the plurality of second conduits are adapted to receive a second medium at a first end of the second conduits and discharge the second medium at a second end of the second conduits through a plurality of radially distributed discharge nozzles.

5. The tuyere of claim 4 wherein the first discharge nozzle is a convergent/divergent nozzle or a convergent nozzle.

6. The tuyere of claim 4 wherein the plurality of radially distributed nozzles are convergent/divergent nozzles or convergent nozzles, at a diverting angle of some degree from the axial direction of the flow from a central shaft.

7. The tuyere of claim 4 further comprising at least one third conduit extending through the tuyere body, wherein the third conduit is adapted to receive a third medium at a first end of the third conduit and discharge the third medium at a second end of the third conduit through at least one third discharge nozzle.

8. The tuyere of claim 7 wherein the at least one third conduit is arranged concentrically around the first conduit.

9. The tuyere of claim 7 wherein the third conduit comprises a plurality of channels radially distributed around the first conduit.

10. A tuyere for use in an oxygen blast furnace system comprising a body and an inner shaft defining a steam opening at an outboard end, wherein the inner shaft is displaceable inwardly or outwardly of the body to adjust the size of the steam opening.

11. The tuyere of claim 1 which is retrofitted to an existing tuyere by inserting a metal plug inside the existing tuyere without requiring modification to the existing tuyere.

12. The tuyere of claim 11 wherein at least one of existing blowpipe shell geometry, attachment mechanisms, and mating mechanisms are retained from the existing tuyere.

13. The tuyere of claim 4 which is retrofitted to an existing tuyere by inserting a metal plug inside the existing tuyere without requiring modification to the existing tuyere.

14. The tuyere of claim 13 wherein at least one of existing blowpipe shell geometry, attachment mechanisms, and mating mechanisms are retained from the existing tuyere.

15. A portable oxygen blast furnace system comprising an oxygen blast furnace secured to a railcar.

16. The portable oxygen blast furnace system of claim 15 wherein the furnace system comprises a tuyere having a body; a first conduit extending through a longitudinal center portion of the body, wherein the first conduit has an outboard end external to the furnace and an inboard end extending into the furnace, wherein the first conduit is adapted to receive a first medium at the outboard end and discharge the first medium at the inboard end through a first discharge nozzle inside the furnace; a second conduit arranged concentrically around the first conduit, wherein the second conduit is adapted to receive a second medium at a first end of the second conduit and discharge the second medium at a second end of the second conduit through a second discharge nozzle.

17. The portable oxygen blast furnace system of claim 15 wherein the furnace system comprises a tuyere comprising a body; a first conduit extending through a longitudinal center portion of the body, wherein the first conduit has an outboard end external to the furnace and an inboard end extending into the furnace, wherein the first conduit is adapted to receive a first medium at the outboard end and discharge the first medium at the inboard end through a first discharge nozzle inside the furnace; wherein the first conduit is adapted to receive a first medium at a first end of the first conduit and discharge the first medium at a second end of the first conduit through a first discharge nozzle; a plurality of secondary conduits extending through the tuyere body, wherein the plurality of second conduits are adapted to receive a second medium at a first end of the second conduits and discharge the second medium at a second end of the second conduits through a plurality of radially distributed discharge nozzles.

18. The portable oxygen blast furnace system of claim 17 further comprising at least one third conduit extending through the tuyere body, wherein the third conduit is adapted to receive a third medium at a first end of the third conduit and discharge the third medium at a second end of the third conduit through at least one third discharge nozzle.

19. A method of processing waste or other raw material comprising transporting a portable oxygen blast furnace system on a railcar to the vicinity of the waste or other raw material, and processing the waste or other raw material in the portable oxygen blast furnace system.

20. The method of claim 19 wherein the portable oxygen blast furnace system is partially dissembled in transit, the method further comprising reassembling the furnace system and preparing a foundation for the furnace system while on the railcar.

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