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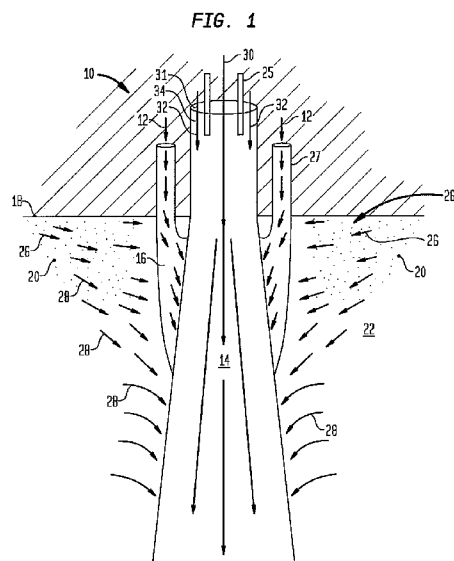
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(54) Title: BURNER FOR REDUCING WALL WEAR IN A MELTER



(57) Abstract: A combustion gas flow for an atmosphere of a melter includes a first gas flow at a first velocity introduced into the atmosphere, and a second gas flow at a second velocity less than the first velocity introduced into the atmosphere for entraining corrosive or condensable vapors in the atmosphere and shrouding and inhibiting the first gas flow from entraining condensable or corrosive vapors at a higher rate than the second gas flow.

SPECIFICATION

BURNER FOR REDUCING WALL WEAR IN A MELTER

[0001] The embodiments relate to the entrainment of the atmosphere in a melter by jets.

[0002] As the velocity of a jet is increased in an atmosphere of a furnace or a melter, the surrounding atmosphere including condensable and corrosive vapors are pulled into the jet at an increased rate. In the case where a jet issues from an opening in a wall of the furnace or melter, the entrainment of the jet in the region proximate the wall requires material be drawn into the jet stream substantially parallel, if not parallel, to the wall surface. If the jet is moving at a high velocity rate, the rate of entrainment is high and consequently the velocities of the atmosphere flowing parallel to the wall surface and containing the condensable and corrosive species will therefore also be high, thereby resulting in increased wear or chemical attack on the wall or crown surface.

[0003] In order to reduce refractory wear in the melter, one could reduce overall jet velocity, but such would limit the total jet momentum in the melter, which would in turn affect flame characteristics, stability or deflection by existing currents in the furnace combustion atmosphere. Use of different refractory materials to counteract such would require increased or additional costs and could raise material compatibility issues with either the glass product, leading to defects, or with other materials of construction of the furnace wall, leading to more frequent repair of the existing melter, thereby resulting in down time of the melter and attendant production losses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] For a more complete understanding of the present embodiments, reference may be had to the following description taking in conjunction with the drawings, of which:

[0005] FIG. 1 shows a burner embodiment for use in a melter.

[0006] FIG. 2 shows a table of the burner embodiment characteristics.

DESCRIPTION OF THE INVENTION

[0007] Referring to FIG. 1, embodiments of the burner are shown generally at 10. The burner 10 generates a central higher velocity jet type flame 14 surrounded by a low velocity shroud 16. The central higher velocity flame jet 14 comprises a combusting flow or flame formed by the combination of a natural gas stream 30 and an oxygen stream 32. The natural gas stream 30 is delivered through a pipe 25 that terminates within a cavity 34 of the burner 10. The oxygen stream 32 is delivered through a passage 31 formed between the pipe 25 and a wall of the cavity 34 of the burner 10.

[0008] The burner 10 introduces a low velocity shroud stream 12 of oxygen through conduit 27 to form a surrounding or outer low velocity shroud 16 around the central higher velocity flame jet 14, wherein the high velocity flame jet 14 entrains the surrounding or outer low velocity shroud 16 near a wall 18 of a furnace or melter, while the low velocity shroud 16 entrains material 20 from the immediate surrounding atmosphere 22 at a substantially lower rate than the high velocity flame jet 14 entrains material 28 from the surrounding atmosphere 22 distant from wall 18. The shroud 16 – traveling at a lesser velocity than the velocity flame jet 14 – is entrained into said flame jet 14. In this manner,

velocities of surrounding atmosphere currents 26 near the wall 18 in the vicinity of the jet-shroud 14,16 combination are reduced. Currents 28 in the atmosphere 22 are of a higher velocity further away from the wall 18.

[0009] The burner 10 reduces chemical wear of refractories surrounding for example oxy-fuel burners – in particular silica attack in soda-lime furnaces. Reducing the velocity of the furnace atmosphere near silica walls, such as the wall 18, of a melter will reduce the attack by chemical species contained in the furnace atmosphere, such as alkali vapors, on the walls.

[0010] The embodiments reduce the velocity of the corrosive furnace atmosphere near burners in glass furnaces or other types of melters. That is, condensable vapors in the furnace atmosphere 22 which would otherwise degrade the furnace wall 18 or crown are limited in their ability to do so, as the reduced velocity shroud 16 entrains said condensable vapors contained within material 20 at a reduced rate. This reduces the rate of chemical attack of, for example, silica by sodium hydroxide or sulphate species transported to the wall surface by the furnace atmosphere currents. This will result in longer furnace life before repair.

[0011] The outer shroud 16 has a composition similar to an external portion of the central flame jet 14. With a pipe-in-pipe burner with a center natural gas stream 30 and an outer oxygen stream 32, the outer shroud 16 is also comprised of oxygen and such would be introduced external to the cavity 34 that confines the initial flame jet 14.

[0012] Velocities of the central natural gas stream 30 and oxygen stream 32 are approximately equal (within 10% of each other). The outer shroud 16 includes approximately 10-50% of the total oxygen supplied and at an initial

velocity is approximately equal to 10-50% of that of the oxygen stream 32 supplied through the central cavity 34 of the burner.

[0013] Suitable fuels for combustion may be gaseous, atomized liquid or a suspended particulate solid. Suitable gaseous fuels include, but are not limited to methane, natural gas, liquefied natural gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof. Suitable liquid fuels include, but are not limited to heavy fuel oil, medium fuel oil, light fuel oil, kerosene, diesel or mixtures thereof. Suitable suspended particulate solid fuels include, but are not limited to coal, coke, petroleum coke, rubber, woodchips, sawdust, straw, biomass fuels or mixtures thereof suspended in a carrier gas selected from air, nitrogen, carbon dioxide or a gaseous fuel, the gaseous fuel selected from methane, natural gas, liquefied natural gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof.

[0014] Preferred oxidants for use with the embodiments include oxygen-enriched air, containing greater than 20.9 volume percent oxygen to about 80 volume percent, preferably greater than 50 volume percent, such as produced by filtration, absorption, membrane separation, or the like; non-pure oxygen such as that produced by, for example, a vacuum swing adsorption process and containing about 80 volume percent to 95 volume percent oxygen; and "industrially" pure oxygen containing about 90 volume percent to about 100 volume percent oxygen, such as produced by a cryogenic air separation unit (ASU) or plant.

[0015] In the Example below, computational fluid dynamic modeling was performed on a pipe-in-pipe burner 10, wherein an initial flame jet 14 is formed by the interaction of a methane 30 stream issuing from the pipe 25 and a

surrounding annular pure oxygen stream 32, both contained within the cavity 34 within a refractory burner block. The pipe 25 carrying the methane is set back within the cavity 34 within a refractory burner block and a flame jet 14 is formed in the cavity 34 between the resultant co-flowing methane 30 and oxygen 32 streams. A shroud stream 12 of oxygen is introduced surrounding the central cavity 34 via an annular conduit 27 to form an oxygen shroud 16 surrounding the central flame jet 14. The relevant dimensions for a range of shroud stream 12 flowrates and initial shroud 16 velocities were determined using the following fixed variables.

[0016] Examples

Methane volumetric flow rate(stream 30): 184Nm³/hr.

Total Oxygen volumetric flow rate (stream 32+ stream 12): 377.2Nm³/hr.

Fuel velocity (stream 30): 30.48m/s.

Central Oxygen velocity (stream 32): 30.48m/s.

Internal diameter of pipe 25 carrying the fuel: 47.96mm.

External diameter of pipe 25 carrying the fuel: 54.31mm.

Distance the tip of pipe 25 is recessed from the discharge end of burner block cavity 34: 152.4mm.

Distance between cavity wall 34 and inside edge of shroud conduit 27: 19.05mm.

[0017] Referring to FIG. 2, a series of examples based on the above fixed variables and the shroud parameters were examined to determine the effect of the proportion of the oxygen delivered via shroud stream 12 and the oxygen shroud 16 velocity on the entrainment of the atmosphere 22. FIG. 2 shows in a table 40 the volume of gases that are entrained near the wall 18. This is determined by the volume of gases flowing across a hypothetical cylindrical boundary of radius 154.2mm co-axial with burner 10 and extending 152.4mm

from the wall 18. As can be seen, the design of the shroud 16 has a significant effect on the volume of gases entrained across the cylindrical boundary and drawn along the wall 18 and into the flame jet 14. As a result, local velocities in the vicinity of the wall 18 and the burner 10 are accordingly reduced.

[0018] In the Table 40 of FIG. 2, columns I – VIII shown generally at 42-56, respectively, represent:

- I. Reference number for Examples 1-9 (42).
- II. The percentage of the total oxygen flow that is delivered as outer shroud 16 via stream 12 (44).
- III. The initial velocity of the outer shroud 16 expressed as a fraction of the initial central oxygen stream 32 velocity (46).
- IV. The diameter of the cavity 34 through which the central flame jet 14 issues (48).
- V. The inner diameter of the annular shroud passage 27 (50).
- VI. The outer diameter of the annular shroud passage 27 (52).
- VII. The volume of the atmospheric gas 22 that is entrained into the initial region of the shroud 16 and central flame jet 14 (54).
- VIII. The percentage reduction in the volume of gas entrained (VII) from the Example 1, where there was no shroud (56).

[0019] By way of example, Example 1 represents a base case for the burner 10 without the shroud 16 to which later Examples 2-9 are compared. Columns II and III show, for Example #1, that no oxygen is diverted to the annular shroud 16. Column IV is the diameter, of the burner block cavity 34 into which issues the fuel stream 30 and oxygen stream 32. This is obtained by determining the annular flow passage area 31 required between the outside of the fuel feed pipe 25 and the inside of the burner block cavity 34 so that an oxygen stream 32

velocity of 30.48m/s is obtained. In this example, as all the oxygen flows through the annular region 31 the area is such that a burner block cavity 34 diameter of 87.5mm is required. Columns V, VI and VIII are blank as there is no shroud 16. Column VII shows that in this case with all of the oxygen issuing at high velocity through stream 32 that a volume of 0.123m³/h is entrained into the initial region of the burner 10 near the wall 18.

[0020] Example 4 is where 30% of the total oxygen is delivered through the shroud 16 at a velocity of 0.3 times that of the central oxygen stream 32, ie a shroud stream 12 flow rate of 113.2Nm³/hr at an initial shroud 16 velocity of 0.3 x 30.48 = 9.1m/s. Column IV represents the reduced diameter of the burner block cavity 34 to accommodate the smaller flow area required for the smaller volume of oxygen (stream 32) issuing into the central burner block cavity 34. Here the flowrate of oxygen stream 32 into the central cavity 34 of the burner block has been reduced from 377.2Nm³/hr to 264Nm³/hr and with the constant oxygen velocity of 30.48m/s of stream 32 the diameter of the burner block cavity 34 is accordingly reduced from 87.5mm in Example 1 to 79.1mm. Column V shows that the inner diameter of the annular conduit 27 is 117.2mm, by adding the constant distance of 19.05mm to the diameter of the burner block cavity 34. Column VI shows the outer diameter of the annular conduit 27 as being 135.8mm, this being determined by the area needed to flow the 4305scfh shroud stream 12 oxygen at an initial shroud 16 velocity of 9.1m/s. Column VII shows the result that the volume of gas entrained into the initial region of the jet is reduced to 0.078m³/s. Column VIII shows that the volume entrained has been reduced by 37% from Example 1 where there was no shrouding.

[0021] The least significant factor appears to be increasing the initial velocity of the shroud 16 (comparing Examples 2, 6 and 7 with Example 1) at a constant

low shroud flow volumes (stream 12) of 10% of the total oxygen flowrate where an approximate 10% reduction in volume entrained is observed.

[0022] A more significant effect is seen when increasing the amount of flow stream 12 to the low velocity shroud 16 (comparing Examples 2, 8 and 9 with Example 1) where up to a 50% reduction in entrained volume is achievable while maintaining a low constant initial shroud 16 velocity of $0.1 \times$ the initial central fuel and oxygen velocities (streams 30, 32).

[0023] From a practical standpoint in some applications a very low velocity shroud 16 passing a significant volume of the total oxygen flow may result in excessively large dimensions for the conduit 27 (e.g. Example 9) which may be prohibitive for installation and it may be preferable to operate an intermediate velocity shroud 16 with a modest shroud stream 12 proportion to be dimensionally reasonable. It is observed that a 30% volume from stream-shroud 12,16 combination flowing at 30% of the central fuel and oxygen streams 30,32 velocities performs well with a 37% reduction in entrained volume.

[0024] A further benefit is obtained in reducing the transport of condensable species within the furnace atmosphere to the outer edge of high velocity oxy-fuel burners. By reducing the rate of entrainment of the furnace atmosphere, the rate of transport of condensable species to the oxy-fuel burner is reduced and the rates of condensation and deposition of material is reduced. Such species can condense and produce a build up of material around the burner that can deflect the flame and cause refractory damage. By reducing or eliminating the build up of material, burner maintenance needs are reduced and the risk of damage through flame deflection is reduced.

[0025] It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as described herein. It should be understood that the embodiments described above are not only in the alternative, but may be combined.

CLAIMS

What is claimed is:

1. A burner for reducing wear on a wall of a melter, comprising:

a first flow path extending through the wall into a combustion atmosphere of the melter, the first flow path providing a fuel stream surrounded by an oxidant stream for providing a first jet with a first velocity in the combustion atmosphere;

a second flow path about the first flow path and extending through the wall into the combustion atmosphere, the second flow path being entrained into the first flow path for providing a second jet with a second velocity less than the first velocity to entrain material from an adjacent region of the combustion atmosphere proximate the wall into the second jet at a reduced rate and shroud and inhibit the first jet from entraining material from the adjacent region of the combustion atmosphere proximate the wall to reduce chemical wear, abrasion and deposition on the wall.

2. The burner according to claim 1, wherein the oxidant stream comprises at least one of oxygen-enriched air, non-pure oxygen or industrially pure oxygen; and the fuel stream comprises a gaseous fuel selected from at least one of methane, natural gas, liquefied natural gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof.

3. The burner according to claim 1, wherein the oxidant stream comprises at least one of oxygen-enriched air, non-pure oxygen and industrially pure oxygen; and the fuel stream comprises a liquid fuel selected from at least one of heavy fuel oil, medium fuel oil, light fuel oil, kerosene, diesel or mixtures thereof.

4. The burner according to claim 1, wherein the oxidant stream comprises at least one of oxygen-enriched air, non-pure oxygen and industrially pure oxygen; and the fuel stream comprises a particulate fuel selected from at least one of coal, coke, petroleum coke, rubber, woodchips, sawdust, straw, biomass fuels or mixtures thereof suspended in a carrier gas stream, the carrier gas stream comprising at least one of air, nitrogen, carbon dioxide or a gaseous fuel.
5. The burner according to claim 4, wherein the gaseous fuel comprises at least one of methane, natural gas, liquefied natural gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof.
6. The burner according to claim 1, wherein the second jet comprises an oxidant selected from at least one of oxygen-enriched air, non-pure oxygen or industrially pure oxygen.
7. The burner according to claim 1, wherein the second flow path is constructed and arranged to surround the first flow path.
8. The burner according to claim, 1 wherein the first and second flow paths are coaxial.
9. The burner according to claim 1, further comprising a first passageway for containing the first flow path, and a second passageway for containing the second flow path.
10. The burner according to claim 1, wherein the first velocity and the second velocity are within 10-50 percent of each other.

11. The burner according to claim 1, wherein the second jet comprises 10-50 percent of a total amount of oxidant supplied to the burner.

12. A combustion gas flow for an atmosphere of a melter, comprising a first gas flow at a first velocity introduced into the atmosphere, and a second gas flow at a second velocity less than the first velocity introduced into the atmosphere for entraining corrosive or condensable vapors in the atmosphere and shrouding the first gas flow from entraining corrosive or condensable vapors from the surrounding atmosphere at a higher rate than the second gas flow.

13. A method of reducing wear on a wall of a melter, comprising:

providing a first flow at a first velocity into a combustion atmosphere of the melter;

providing a second flow at a second velocity less than the first velocity into the combustion atmosphere of the melter;

shrouding the first flow with the second flow to entrain material in the combustion atmosphere adjacent the wall into the second flow and prevent the first flow from entraining material in the combustion atmosphere adjacent the wall at a higher rate than the second flow.

14. The method according to claim 13, wherein the first flow comprises a fuel stream surrounded by an oxidant stream.

15. The method according to claim 14, wherein the fuel stream comprises a gaseous fuel selected from at least one of methane, natural gas, liquefied natural

gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof.

16. The method according to claim 14, wherein the fuel stream comprises a liquid fuel selected from at least one of heavy fuel oil, medium fuel oil, light fuel oil, kerosene, diesel or mixtures thereof.

17. The method according to claim 14, wherein the fuel stream comprises a particulate fuel selected from at least one of coal, coke, petroleum coke, rubber, woodchips, sawdust, straw, biomass fuels or mixtures thereof suspended in a carrier gas stream, the carrier gas stream comprising at least one of air, nitrogen, carbon dioxide or a gaseous fuel.

18. The method according to claim 17, wherein the gaseous fuel comprises at least one of methane, natural gas, liquefied natural gas, propane, liquefied propane gas, butane, low BTU gases, town gas, producer gas or mixtures thereof.

19. The method according to claim 13, wherein the second flow comprises an oxidant selected from at least one of oxygen-enriched air, non-pure oxygen or industrially pure oxygen.

20. The method according to claim 13, further comprising containing the first flow in a first conduit external to the combustion atmosphere, and the second flow in a second conduit external to the combustion atmosphere.

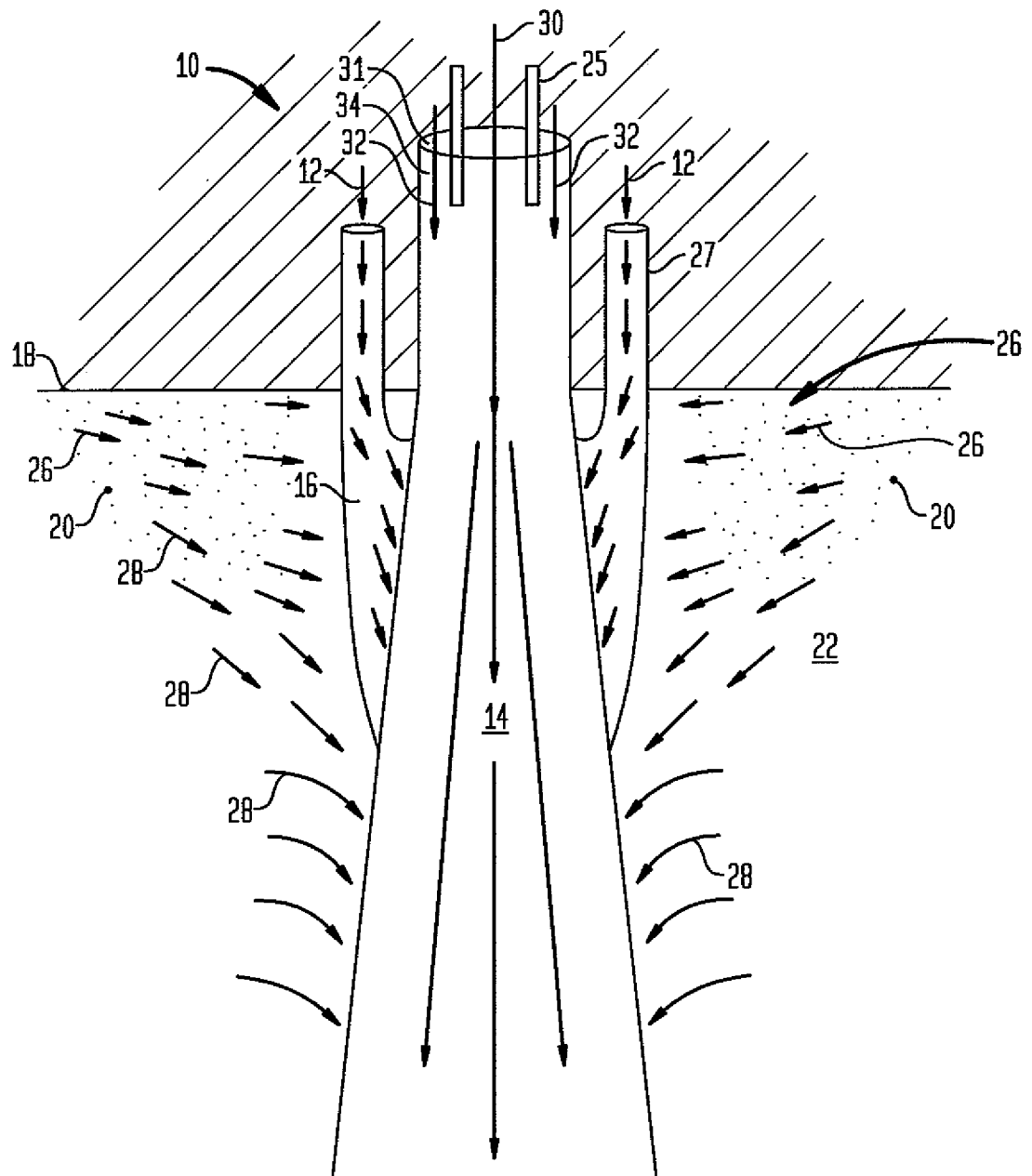
FIG. 1

FIG. 2

I	II	III	IV	V	VI	VII	VIII
EXAMPLE #	TOTAL O ₂ IN SHROUD (%)	$u_{\text{(SHROUD)}}/u_{\text{(OX)}}$	BURNER BLOCK INTERNAL DIAMETER (mm)	INNER DIAMETER OF SHROUD (mm)	OUTER DIAMETER OF SHROUD (mm)	VOLUME ENTRAINED (m ³ /s)	REDUCTION IN VOLUME ENTRAINED (%)
1	0	0	87.5	-	-	0.123	-
2	10	0.1	84.8	122.9	140.8	0.110	11%
3	20	0.2	82.0	120.1	138.3	0.091	26%
4	30	0.3	79.1	117.2	135.8	0.078	37%
5	50	0.5	72.8	110.9	130.5	0.082	33%
6	10	0.3	84.8	122.9	129.1	0.109	11%
7	10	0.5	84.8	122.9	126.7	0.111	10%
8	30	0.1	79.1	117.2	166.9	0.073	41%
9	50	0.1	72.8	110.9	189.4	0.062	50%

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/026512

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F23D 14/32 (2010.01)

USPC - 431/187

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(8) - F23D 14/22, 14/32 (2010.01)

USPC - 431/10, 187, 188

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

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

USPTO EAST System (US, USPG-PUB, EPO, DERWENT)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,254,379 B1 (BOOL, III et al) 03 July 2001 (03.07.2001) entire document	1, 2, 4-15, 17-20
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Y		3, 16
Y	US 6,705,117 B2 (SIMPSON et al) 16 March 2004 (16.03.2004) entire document	3, 16
A	US 5,295,816 A (KOBAYASHI et al) 22 March 1994 (22.03.1994) entire document	1-20
A	US 6,190,158 B1 (LEGIRET et al) 20 February 2001 (20.02.2001) entire document	1-20
A	US 5,878,676 A (JOCHER et al) 09 March 1999 (09.03.1999) entire document	1-20

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Date of the actual completion of the international search

26 April 2010

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