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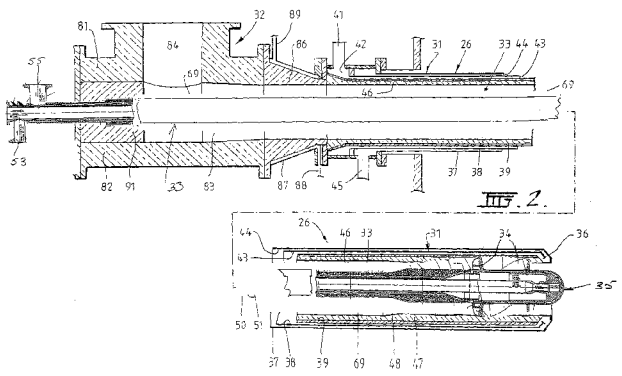
(54) Title: APPARATUS FOR INJECTING GAS INTO A VESSEL



(57) Abstract: An apparatus for injecting gas into a vessel is disclosed. The apparatus comprises a gas flow duct from which to discharge gas from the duct, an elongate central structure extending within the gas flow duct from its rear end to its forward end, and a plurality of flow directing vanes disposed about the central structure adjacent the forward end of the duct. The forward end of the central structure and the vanes are water cooled by separate supply passages.

APPARATUS FOR INJECTING GAS INTO A VESSEL

Field of the Invention

The present invention relates to an apparatus for injecting gas into a vessel. It has particular, but not exclusive application to apparatus for injecting a flow of gas into a metallurgical vessel under high temperature conditions. Such metallurgical vessel may for example be a smelting vessel in which molten metal is produced by a direct smelting process.

A known direct smelting process, which relies on a molten metal layer as a reaction medium, and is generally referred to as the HIsmelt process, is described in United States Patents 6,440,356 and 6,673,305.

The HIsmelt process comprises:

(a) forming a bath of molten metal in the form of iron and slag in a vessel;

(b) injecting into the bath:

(i) a metalliferous feed material, typically metal oxides; and

(ii) a solid carbonaceous material, typically coal, which acts as a reductant of the metal oxides and a source of energy; and

(c) smelting metalliferous feed material to metal in the metal layer.

The term "smelting" is herein understood to mean thermal processing wherein chemical reactions that reduce metal oxides take place to produce liquid metal.

The HIsmelt process also comprises post-combusting reaction gases, such as CO and H_2 released from the bath in the space above the bath with oxygen-containing gas and

transferring the heat generated by the post-combustion to the bath to contribute to the thermal energy required to smelt the metalliferous feed materials.

The HIsmelt process also comprises forming a transition zone above the nominal quiescent surface of the bath in which there is a favourable mass of ascending and thereafter descending droplets or splashes or streams of molten metal and/or slag which provide an effective medium to transfer to the bath the thermal energy generated by post-combusting reaction gases above the bath.

In the HIsmelt process the metalliferous feed material and solid carbonaceous material is injected into the metal layer through a number of lances/tuyeres which are inclined to the vertical so as to extend downwardly and inwardly through the side wall of the smelting vessel and into the lower region of the vessel so as to deliver the solids material into the metal layer in the bottom of the vessel. To promote the post combustion of reaction gases in the upper part of the vessel, a blast of hot air, which may be oxygen enriched, is injected into the upper region of the vessel through the downwardly extending hot air injection lance. To promote effective post combustion of the gases in the upper part of the vessel, it is desirable that the incoming hot air blast exit the lance with a swirling motion. To achieve this, the outlet end of the lance may be fitted with internal flow guides to impart an appropriate swirling motion. The upper regions of the vessel may reach temperatures of the order of 2000°C and the hot air may be delivered into the lance at temperatures of the order of 1100-1400°C. The lance must therefore be capable of withstanding extremely high temperatures both internally and on the external walls, particularly at the delivery end of the lance which projects into the combustion zone of the vessel.

The present invention provides a lance construction which enables the relevant components to be internally water cooled and to operate in a very high temperature environment.

Summary of the Invention

According to the invention, there is provided an apparatus for injecting gas into a vessel, comprising:

a gas flow duct extending from a rear end to a forward end from which to discharge gas from the duct;

an elongate central structure extending within the gas flow duct from its rear end to its forward end;

a plurality of flow directing vanes disposed about the central structure adjacent the forward end of the duct to impart swirl to a gas flow through the forward end of the duct, the forward end of the central structure and the forward end of the duct co-acting together to form an annular nozzle for flow of gas from the duct with swirl imparted by the vanes;

first cooling water flow passage means located within the forward end of the central structure for flow of cooling water to internally water cool outer surfaces of the forward end of the central structure;

second cooling water flow passage means located within the vanes for flow of cooling water to internally water cool the vanes;

a first cooling water supply passage within the central structure for supplying a first flow of cooling water forwardly through the central structure from its rear end and into the first cooling water flow passage means in the forward end of the central structure;

a second cooling water supply passage within the central structure for supplying a second separate flow of cooling water forwardly through the central structure from its rear end and into the second cooling water flow passage means within the vanes; and

water flow return passage means within the central structure for return flow of water from the first and second cooling water flow passage means.

The water return passage means may comprise a single flow passage for return flow of water from both the first and second cooling water passage means.

The first cooling water supply passage may extend as a central passage through the central structure for flow of water directly to the forward end of the central structure.

The first cooling water supply passage may extend through the central structure for flow of water directly to a tip of the forward end of the central structure.

The second cooling water supply passage may comprise an annular passage formed within the central structure about the first supply passage.

The water return passage means may comprise a further annular passage formed within the central structure outside the annular second cooling water supply passage.

The forward end of the central structure may include a domed nose portion and the first cooling water flow passage means may comprise a cooling water flow passage extending from the tip of the nose for flow of cooling water around and backwardly along the nose.

The cooling water flow passage of the first cooling water flow passage means may extend in a spiral formation backwardly from the nose. More specifically that passage may extend in a single spiral extending from the tip of the nose to direct water in a single flow around and

backwardly along the nose to cool the nose with a single coherent stream of cooling water.

The cooling water flow passage of the first cooling water flow passage means may extend backwardly from the nose and within the outer periphery of that part of the central structure about which the vanes are disposed.

The cooling water flow passage of the first cooling water flow passage means may bypass the water flow path from the second water supply passage to the second cooling water flow passage means within the vanes.

A forward portion of the second cooling water supply passage may be formed as an arcuate passage having first and second end portions separated by an arcuate region of extent greater than 180 degrees and less than 360 degrees and a segmental region between the first and second end portions, and wherein the cooling water flow passage of the first cooling water flow passage means may extend within the segmental region and thereby bypass the forward portion of the second cooling water supply passage.

The cooling water flow passage of the first cooling water flow passage means may include an inward lateral step that bypasses the water flow path from the second water supply passage to the second cooling water flow passage means within the vanes.

The cooling water flow passage of the first cooling water flow passage means may extend backwardly from the diversion and be connected to the water return passage means.

The second cooling water flow passage means may comprise passages in the vanes extending between inlets at forward

ends of the vanes and outlets at rearward ends of the vanes.

The second cooling water supply passage may connect with the vane passage inlets at the forward ends of the vanes.

The vane passage outlets at the rear ends of the vanes may connect with the cooling water return passage means.

Each vane may have a hollow interior divided by baffles defining the vane passage within the vane.

The baffles may be arranged such that the vane passage extends back and forth along the vane so that cooling water flowing from the inlet to the outlet flows in a plurality of passes from the front to the rear end of the vane.

The first pass of each vane passage may extend from the inlet along the outer longitudinal edge of the vane.

The invention also extends to apparatus for location within a gas flow duct through which to inject gas into a vessel, said apparatus comprising:

an elongate structure to extend within the gas flow duct;

a plurality of flow directing vanes disposed about the elongate structure adjacent a forward end of the structure to impart swirl to a gas flow through the duct;

first cooling water flow passage means located within the forward end of the elongate structure for flow of cooling water to internally water cool outer surfaces of the forward end of the elongate structure;

second cooling water flow passage means located within the vanes for flow of cooling water to internally water cool the vanes;

a first cooling water supply passage within the elongate structure for supplying a first flow of cooling water forwardly through the elongate structure from its rear end and into the first cooling water flow passage means in the forward end of the central structure;

a second cooling water supply passage within the elongate structure for supplying a second separate flow of cooling water forwardly through the elongate structure from its rear end and into the second cooling water flow passage means within the vanes; and

water flow return passage means within the elongate structure for return flow of water from the and second cooling water flow passage means.

In order that the invention may be more fully explained, one particular embodiment will be described in detail with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a vertical section through one embodiment of a direct smelting vessel incorporating a pair of solids injection lances and a hot air blast injection lance constructed in accordance with the invention;

Figure 2 is a longitudinal cross-section through the hot air blast injection lance;

Figure 3 is a longitudinal cross-section through a central structure of the lance;

Figure 4 is a longitudinal cross-section through a forward part of the central structure;

Figure 5 is a transverse cross-section on the line 5-5 in Figure 4;

Figures 6 and 7 are side elevations that show the forward part of the central structure with some parts removed for clarity;

Figures 8 is a perspective view of a swirl vane structure mounted on the forward end of the central structure;

Figure 9 is a side elevation of the swirl vane structure;

Figure 10 is a development of one of the swirl vanes in the structure shown in Figures 8 and 9; and

Figure 11 is a transverse cross-section through one of the swirl vanes.

Detailed Description of the Preferred Embodiment

Figure 1 illustrates a direct smelting vessel suitable for operation by the HIsmelt process as described in United States Patents 6,440,356 and 6,673,305. The metallurgical vessel is denoted generally as 11 and has a hearth that includes a base 12 and sides 13 formed from refractory bricks; side walls 14 which form a generally cylindrical barrel extending upwardly from the sides 13 of the hearth and which includes an upper barrel section 15 and a lower barrel section 16; a roof 17; an outlet 18 for off-gases; a forehearth 19 for discharging molten metal continuously; and a tap-hole 21 for discharging molten slag.

In use, the vessel contains a molten bath of iron and slag which includes a layer 22 of molten metal and a layer 23 of molten slag on the metal layer 22. The arrow marked by the numeral 24 indicates the position of the nominal quiescent surface of the metal layer 22 and the arrow marked by the numeral 25 indicates the position of the nominal quiescent surface of the slag layer 23. The term

"quiescent surface" is understood to mean the surface when there is no injection of gas and solids into the vessel.

The vessel is fitted with a downwardly extending hot air injection lance 26 for delivering a hot air blast into an upper region of the vessel and two solids injection lances 27 extending downwardly and inwardly through the side walls 14 and into the slag layer 23 for injecting iron ore, solid carbonaceous material, and fluxes entrained in an oxygen-deficient carrier gas into the metal layer 22. The position of the lances 27 is selected so that their outlet ends 28 are above the surface of the metal layer 22 during operation of the process. This position of the lances reduces the risk of damage through contact with molten metal and also makes it possible to cool the lances by forced internal water cooling without significant risk of water coming into contact with the molten metal in the vessel.

The construction of the hot air injection lance 26 is illustrated in Figures 2 - 11. As shown in these figures lance 26 comprises an elongate duct 31 which receives hot gas through a gas inlet structure 32 and injects it into the upper region of vessel. The lance includes an elongate central tubular structure 33 which extends within the gas flow duct 31 from its rear end to its forward end. Adjacent the forward end of the duct, central structure 33 carries a series of four swirl imparting vanes 34 for imparting swirl to the gas flow exiting the duct. The forward end of central structure 33 has a domed nose 35 which projects forwardly beyond the tip 36 of duct 31 so that the forward end of the central structural 33 and the forward end of the duct co-act together to form an annular nozzle for divergent flow of gas from the duct with swirl imparted by the vanes 34. Vanes 34 form part of a structure 40 comprising a tubular hub 40A about which the

vanes 34 are disposed in a four-start helical formation and are a sliding fit within the forward end of the duct.

The wall of the main part of duct 31 extending downstream from the gas inlet 32 is internally water cooled. This section of the duct is comprised of a series of three concentric steel tubes 37, 38, 39 extending to the forward end part of the duct where they are connected to the duct tip 36. The duct tip 36 is of hollow annular formation and it is internally water cooled by cooling water supplied and returned through passages in the wall of duct 31. Specifically, cooling water is supplied through an inlet 41 and annular inlet manifold 42 into an inner annular water flow passage 43 defined between the tubes 38, 39 of the duct through to the hollow interior of the duct tip 36 through circumferentially spaced openings in the tip. Water is returned from the tip through circumferentially spaced openings into an outer annular water return flow passage 44 defined between the tubes 37, 38 and backwardly to a water outlet 45 at the rear end of the water cooled section of duct 31.

The water cooled section of duct 31 is internally lined with an internal refractory lining 46 that fits within the innermost metal tube 39 of the duct and extends through to the water cooled tip 36 of the duct. The inner periphery of duct tip 36 is generally flush with the inner surface of the refractory lining which defines the effective flow passage for gas through the duct. The forward end of the refractory lining has a slightly reduced diameter section 47 which receives the swirl vanes 34 with a snug sliding fit. Rearwardly from section 47 the refractory lining is of slightly greater diameter to enable the central structure 33 to be inserted downwardly through the duct on assembly of the lance until the swirl vanes 34 reach the forward end of the duct where they are guided into snug engagement with refractory section 47 by a tapered

refractory land 48 which locates and guides the vanes into the refractory section 47.

The hollow interior of duct tip 36 may be divided internally so as to form cooling water flow galleries (not shown) extending circumferentially around the tip in the manner which is more fully disclosed in United States Patent Publication 2006-0108722-A1.

As is to be described in detail with reference to Figures 8 to 11 the swirl vanes 34 are formed with internal cooling water flow passages. The vanes 34 and the front end of central structure 33 are internally water cooled by cooling water supplied forwardly through the central structure from the rear end to the forward end of the lance and then returned back along the central structure to the rear end of the lance. Separate water supply passages extend through the central structure for supply of cooling water to the vanes and to the domed nose 35 so as to enable a strong flow of cooling water directly to the vanes and to the domed nose 35 in particular which are subjected to very high heat flux in operation of the lance.

Central structure 33 comprises a series of three concentric steel tubes 49, 50, 51 each of which is formed by tube segments disposed end to end and welded together. Inner tube 49 defines a central first water flow passage 52 through which water flows forwardly through the central structure from a water inlet 53 at the rear end of the lance through to the front end nose 35 of the central structure. A second water supply passage 54 is formed by the annular space between the inner tube 49 and the intermediate tube 50 through which water can flow through the central structure from a water inlet 60 at the rear end of the lance to internal cooling water flow passages in the swirl vanes 34.

The annular space between the intermediate tube 50 and the outer tube 51 provides a water return passage 56 through which cooling water returns from both the nose 35 of the central structure 33 and the cooling water flow passages in the vanes back through the central structure to a water outlet 55 at the rear end of the lance.

Toward the front end of the central structure 33 the intermediate tube 50 and outer tube 51 flare outwardly at 51A, 52A so that the inner end of the second water supply passage 54 is enlarged. Intermediate tube 51A is extended by an extension tube 80 which is connected to a tubular rear part of a copper body 61 fitted within an outer domed nose shell 62 also formed of copper forming the nose end of central structure 33.

The tubular hub 40A of vane structures fits around the rear end of body 61 and the extension tube 80 immediately behind the nose shell 62. The forward end of vane hub 40A fits onto a circumferential rib 82 formed on the tubular part of copper body 61 and provided with an annular groove 83 which receives water through four circumferentially spaced slots 84 through the tubular part of copper body 61 to serve as a water inlet gallery for supply of cooling water from the expanded inner end of cooling water passage 54 to the cooling water passages in the vanes in the manner to be described below.

Behind rib 82 there is an annular clearance space 90 between the hub 40A of the vane structure and the extension tube 80 and tubular part of copper body 61 which provides an extension of a water flow passage through the front end of the central structure in the manner now to be described.

The inner copper piece 61 of the nose end of the central structure is formed with a central water flow passage 63 connecting through a connector tube 70 with the inner end of central water supply passage 52 to receive water from the duct 52 and direct it to the tip of the nose. Nose piece 61 is formed with projecting ribs 64 which fit snugly within the nose shell 62 to define a single continuous cooling water flow passage 65 between the inner section 61 and the outer nose shell 62. The ribs 64 are shaped so that the single continuous passage 65 extends as annular passage segments 66 interconnected by passage segments 67 sloping from one annular segment to the next. Thus passage 65 extends from the tip of the nose in a spiral which, although not of regular helical formation, does spiral around and back along the nose.

The rear end of copper piece 61 is formed with an integral cylindrical boss 104 within which there extends a short longitudinal passage 85 connected at its forward end with the rear end of the nose cooling water passage 65 through a port 86 and at its rear end through a port 87 with the annular space 90 within the vane structure hub 40A. In effect, this arrangement forms an inward lateral step in the flow passage. Cooling water from passage 65 can thus flow via port 86, passage 85 and port 87 into the annular space 90, so bypassing the outward flow of cooling water to the vanes via the circumferentially spaced slots 84 and the groove 83 in rib 82. More particularly, the cylindrical boss 104 extends through what would have been an annular forward end portion of the second cooling water supply passage 54, with the result that the forward end is an arcuate section 106 as viewed in Figure 5. This arcuate section 106 has first and second end portions 108, 110 separated by the cylindrical boss 104. It can be appreciated from Figure 5 that the arrangement does not restrict water flow from the forward end of the second cooling water supply passage 54 into the slots 84 that

communicate with the annular groove 83 and the cooling water passages in the vanes in the manner to be described below. Annular space 90 is divided by an elongate baffle bar 88 to form a spiraled extension of the cooling water passage 65 extending around the front end of the inner structure immediately within the vaned structure 40 and back to an annular water outlet gallery 89 which connects with the water return passage 56 of the central structure. The water passage 65 and the spiraled extension within the annular space 90 thus form a continuous cooling water flow passage in the forward end of the central structure which extends backwardly from the nose and within the outer periphery of that part of the central structure on which the vanes are mounted so assisting in the cooling of the vane structure, the diversion through passage 85 enabling this passage to bypass the outward flow of cooling water to the vanes.

The forced flow of cooling water in a single coherent stream through spiral passage 65 extending around and back along the nose end 35 of central structure ensures efficient heat extraction and avoids the development of "hot spots" on the nose which could occur if the cooling water is allowed to divide into separate streams at the nose. In the illustrated arrangement the cooling water is constrained in a single stream from the time that it enters the nose end 35 to the time that it exits the nose end.

The construction of vane structure 40 is illustrated in Figures 8 to 11. Each vane is formed by a pair of stainless steel side plates 91 which spiral along hub 40A in the front to rear direction and are separated by a capping bar 92 extended around the outer rim of the vane and a pair of baffle bars 93, 94 which divide the interior of the vane between the side plates into an elongate internal cooling water flow passage 95. The cooling water

passages 95 in vanes 34 extend from inlets 96 formed at the forward ends of the vanes by slots extended through the hub 40A to register with the vane cooling water inlet gallery 83 and outlets 97 formed by slots in the hub 40A at the rear ends of the vanes to register with the water outlet gallery 89 through which water can flow from the vanes back through the water return passage 56 to the rear end of the central structure 33. Baffles 93, 94 are formed such that the water flow passages 95 extend from the inlets 96 backwardly along outer parts of the vanes to the rear end of the vanes then forwardly back to the forward end of the vanes before passing back along the inner parts of the vanes to the outlets 97. Thus incoming cooling water is directed firstly to the outer edges of the vanes which are most susceptible to excessive heating and degradation. The multi-pass flow passages 95 also ensure that all parts of the vanes are effectively cooled and stagnant water flow passages cannot develop.

The internally water cooled stainless steel swirl vanes are very robust and are able to withstand extremely high temperature conditions and abrasion from grit or other material carried by the hot gas blast within the lance. The vanes may be hard faced for maximum life.

Inner structure is provided with an external heat shield 91 formed of refractory material 92 encased within an outer casing 93 of high temperature resistant stainless steel to shield against heat transfer from the incoming hot gas flow in the duct 31 into the cooling water flowing within the central structure 33. The heat shield reduces heat transfer into the water flowing to the inner end of the central structure and the vanes and also insulates the returning water from the hot gas within the lance and hence minimise the load on cooling circuits for the cooling water.

Claims

1. Apparatus for injecting gas into a vessel, comprising:

a gas flow duct extending from a rear end to a forward end from which to discharge gas from the duct;

an elongate central structure extending within the gas flow duct from its rear end to its forward end;

a plurality of flow directing vanes disposed about the central structure adjacent the forward end of the duct to impart swirl to a gas flow through the forward end of the duct, the forward end of the central structure and the forward end of the duct co-acting together to form an annular nozzle for flow of gas from the duct with swirl imparted by the vanes;

first cooling water flow passage means located within the forward end of the central structure for flow of cooling water to internally water cool outer surfaces of the forward end of the central structure;

second cooling water flow passage means located within the vanes for flow of cooling water to internally water cool the vanes;

a first cooling water supply passage within the central structure for supplying a first flow of cooling water forwardly through the central structure from its rear end and into the first cooling water flow passage means in the forward end of the central structure;

a second cooling water supply passage within the central structure for supplying a second separate flow of cooling water forwardly through the central structure from its rear end and into the second cooling water flow passage means within the vanes; and

water flow return passage means within the central structure for return flow of water from the first and second cooling water flow passage means.

2. Apparatus as claimed in claim 1, wherein the water return passage means comprises a single flow passage for return flow of water from both the first and second cooling water passage means.

3. Apparatus as claimed in claim 1 or claim 2, wherein the first cooling water supply passage extends as a central passage through the central structure for flow of water directly to the forward end of the central structure.

4. Apparatus as claimed in claim 3, wherein the first cooling water supply passage extends through the central structure for flow of water directly to a tip of the forward end of the central structure.

5. Apparatus as claimed in claim 3 or claim 4, wherein the second cooling water supply passage comprises an annular passage formed within the central structure about the first cooling water supply passage.

6. Apparatus as claimed in claim 5, wherein the water return passage means comprises a further annular passage formed within the central structure outside the annular second cooling water supply passage.

7. Apparatus as claimed in any one of the proceeding claims, wherein the forward end of the central structure includes a domed nose and the first cooling water flow passage means comprises a cooling water flow passage extending from a tip of the nose for flow of cooling water around and backwardly along the nose.

8. Apparatus as claimed in claim 7, wherein the cooling water flow passage of the first cooling water flow passage means extends in a spiral formation backwardly from the nose.

9. Apparatus as claimed in claim 8, wherein the cooling water flow passage of the first cooling water flow passage means extends in a single spiral extending from the tip of the nose to direct water in a single flow around and backwardly along the nose to cool the nose with a single coherent stream of cooling water.

10. Apparatus as claimed in any one of claims 7 to 9, wherein the cooling water flow passage of the first cooling water flow passage means extends backwardly from the nose and within the outer periphery of that part of the central structure about which the vanes are disposed.

11. Apparatus as claimed in claim 10, wherein the cooling water flow passage of the first cooling water flow passage means includes bypasses the water flow path from the second water supply passage to the second cooling water flow passage means within the vanes.

12. Apparatus as claimed in claim 11, wherein a forward portion of the second cooling water supply passage is formed as an arcuate passage having first and second end portions separated by an arcuate region of extent greater than 180 degrees and less than 360 degrees and a segmental region between the first and second end portions, and wherein the cooling water flow passage of the first cooling water flow passage means extends within the segmental region and thereby bypasses the forward portion of the second cooling water supply passage.

13. Apparatus defined in claim 11 or claim 12 wherein the cooling water flow passage of the first cooling water flow passage means includes an inward lateral step that bypasses the water flow path from the second water supply passage to the second cooling water flow passage means within the vanes.

14. Apparatus as claimed in any one of claims 10 to 13, wherein the cooling water flow passage of the first cooling water flow passage means extends backwardly from the lateral step and is connected to the water return passage means.

15. Apparatus as claimed in any one of the preceding claims wherein the second cooling water flow passage means comprises passages in the vanes extending between inlets at forward ends of the vanes and outlets at rearward ends of the vanes.

16 Apparatus as claimed in claim 15, wherein the second cooling water supply passage connects with the vane passage inlets at the forward ends of the vanes.

17. Apparatus as claimed in claim 16, wherein the vane passage outlets at the rear ends of the vanes connect with or are in close proximity to the cooling water return passage means.

18. Apparatus as claimed in any one of claims 15 to 17 wherein each vane has a hollow interior divided by baffles defining the cooling water passage within the vane.

19. Apparatus as claimed in claim 18, wherein the baffles are arranged such that the cooling water passage extends back and forth along the vane so that cooling water flowing from the inlet to the outlet flows in a plurality of passes from the front to the rear end of the vane.

20. Apparatus as claimed in claim 19, wherein the first pass of each vane passage extends from the inlet along the outer longitudinal edge of the vane.

21. Apparatus for location within a gas flow duct through which to inject gas into a vessel, said apparatus comprising:

an elongate structure to extend within the gas flow duct;

a plurality of flow directing vanes disposed about the elongate structure adjacent a forward end of the structure to impart swirl to a gas flow through the duct;

first cooling water flow passage means located within the forward end of the elongate structure for flow of cooling water to internally water cool outer surfaces of the forward end of the elongate structure;

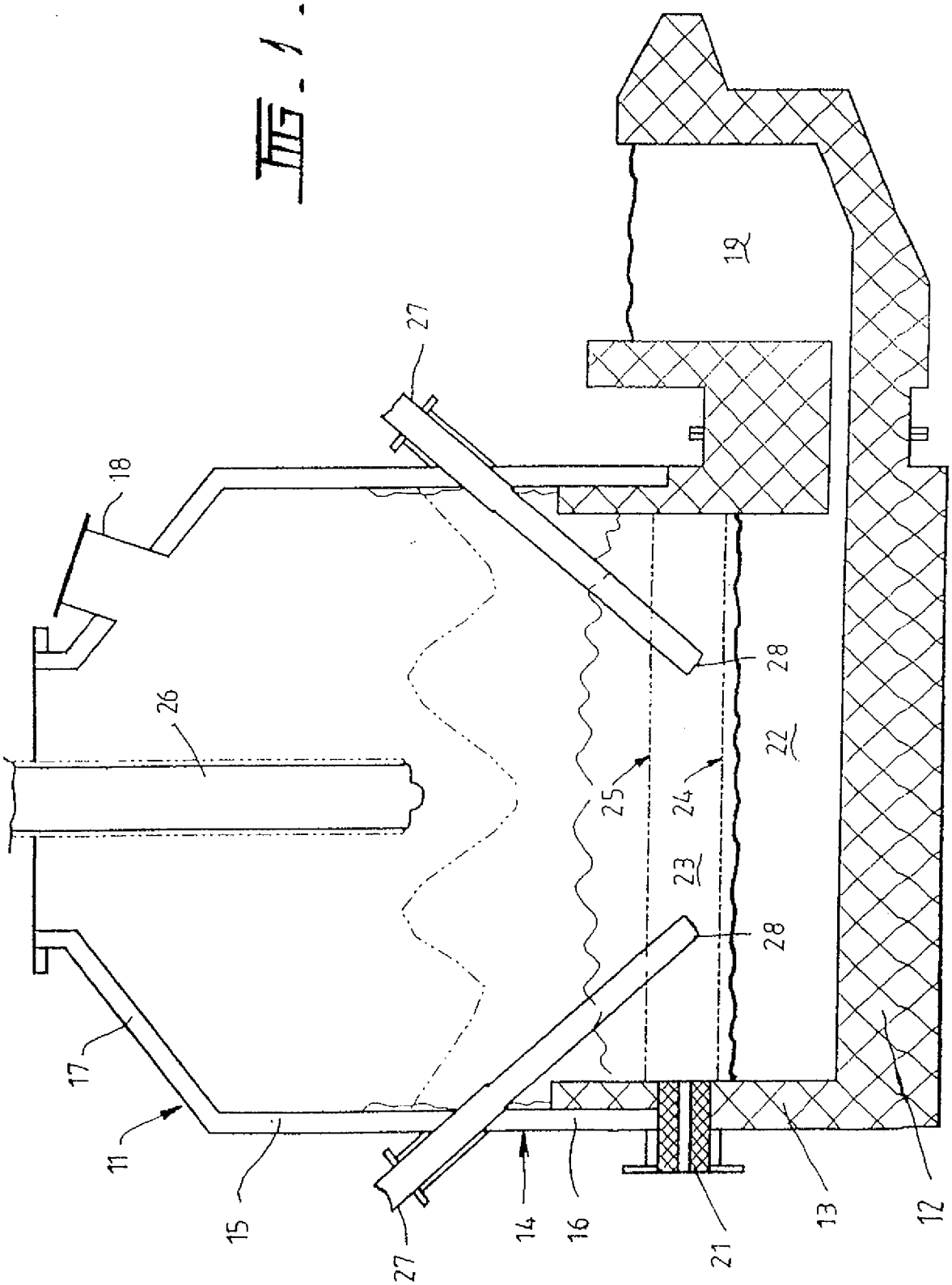
second cooling water flow passage means located within the vanes for flow of cooling water to internally water cool the vanes;

a first cooling water supply passage within the elongate structure for supplying a first flow of cooling water forwardly through the elongate structure from its rear end and into the first cooling water flow passage means in the forward end of the central structure;

a second cooling water supply passage within the elongate structure for supplying a second separate flow of cooling water forwardly through the elongate structure from its rear end and into the second cooling water flow passage means within the vanes; and

water flow return passage means within the elongate structure for return flow of water from the and second cooling water flow passage means.

Fig. 1.



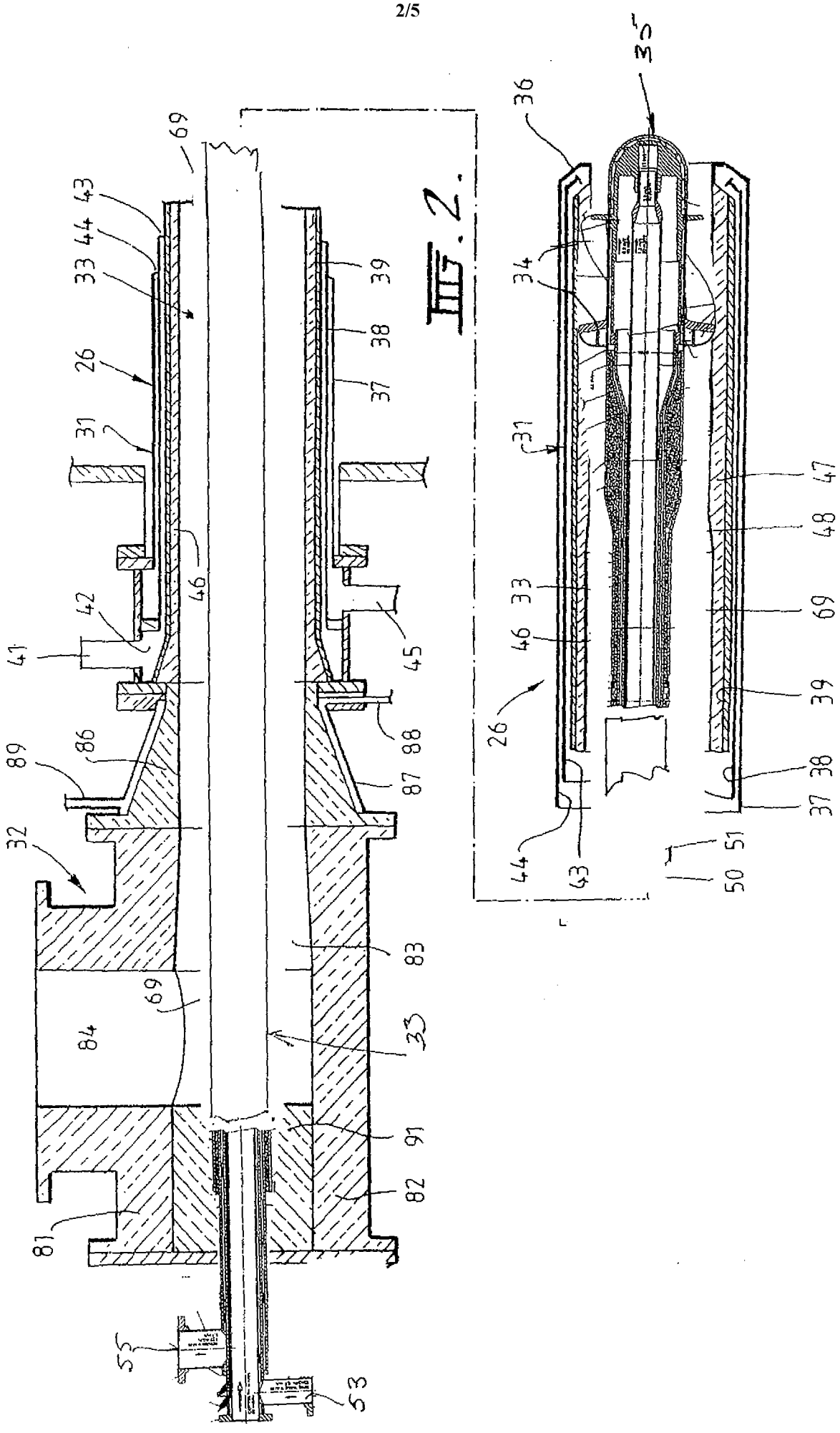

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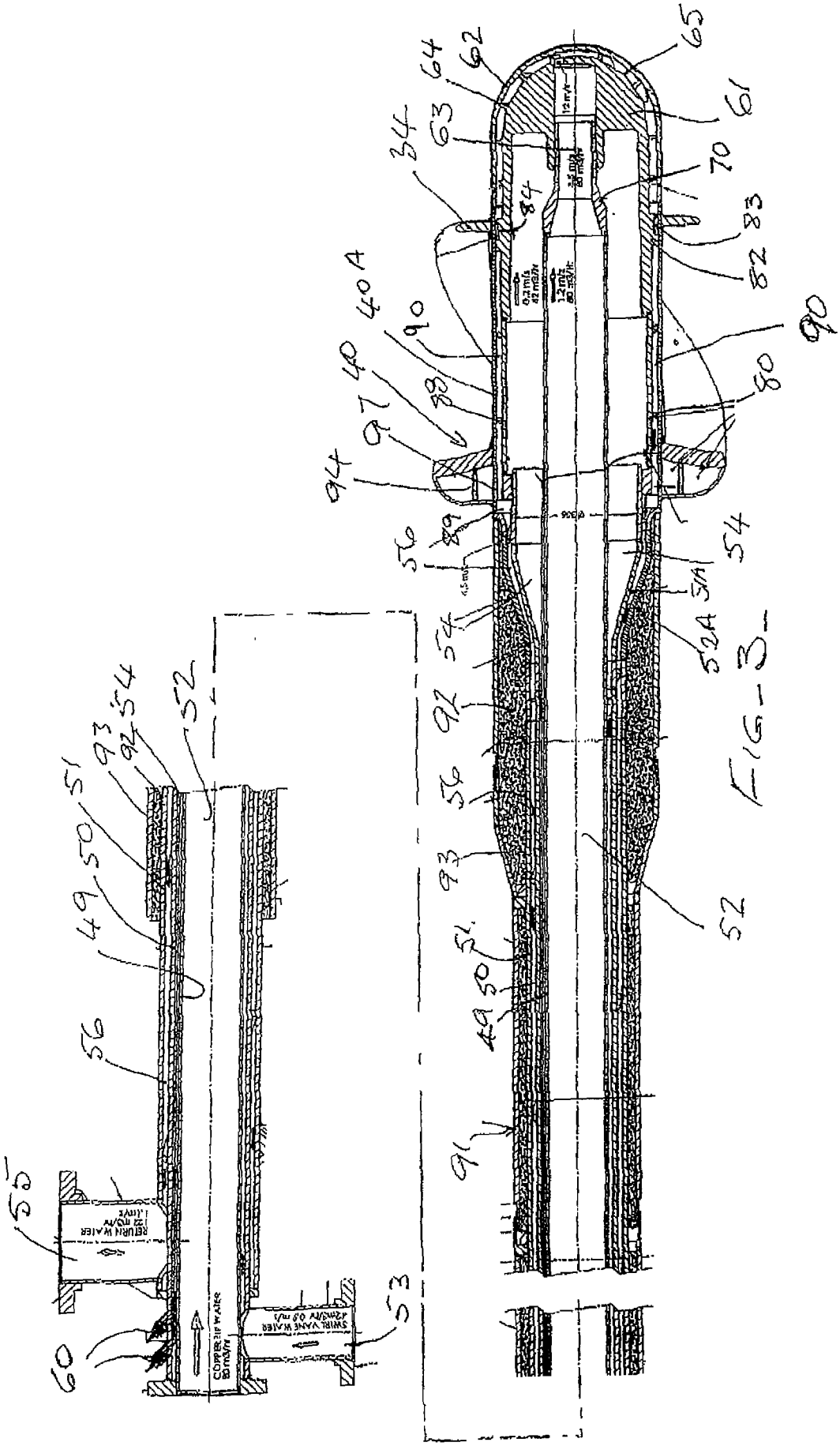
FIG. 2.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40A
40
90
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80
94
97
89
56
54
54A
52A
92
93
52
49
50
51
91
53
60
55
RETURN WATER
SWIRL VANE WATER

FIG-3-

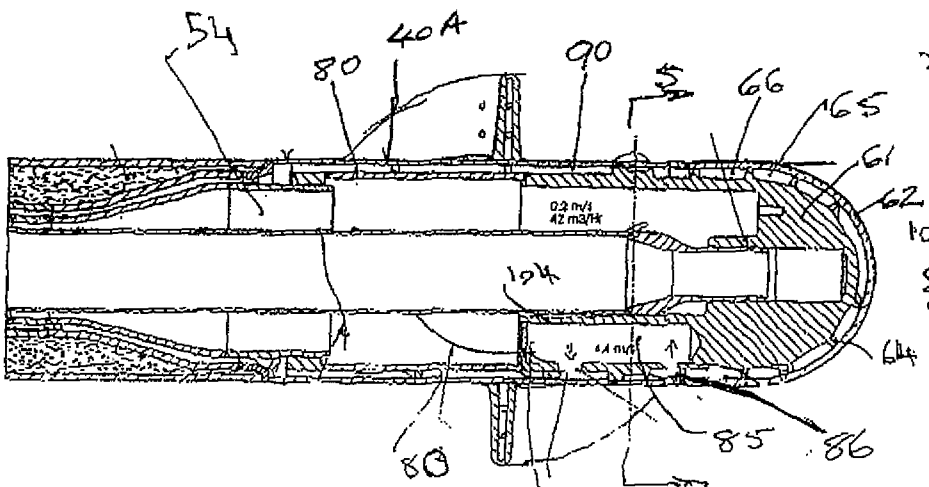

FIG. 4

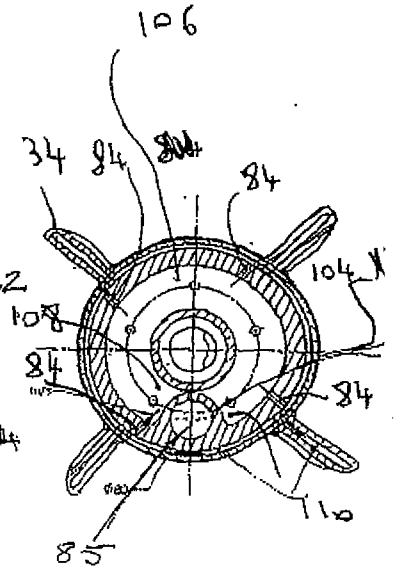

FIG. 5

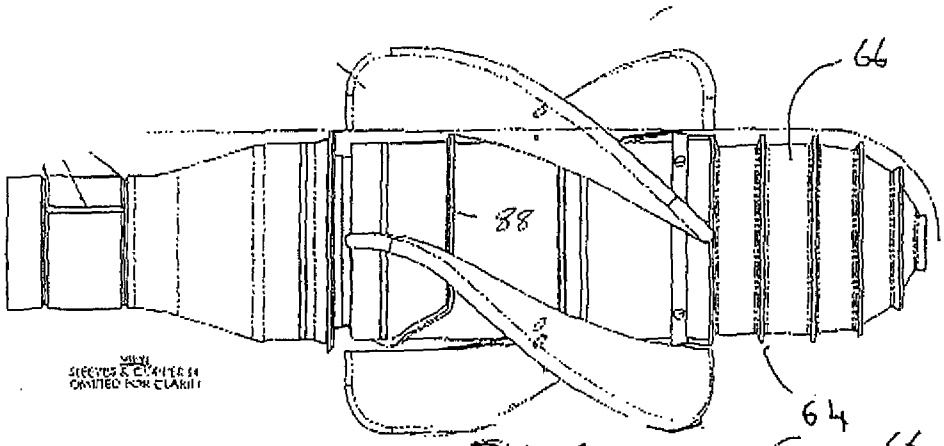

FIG 6

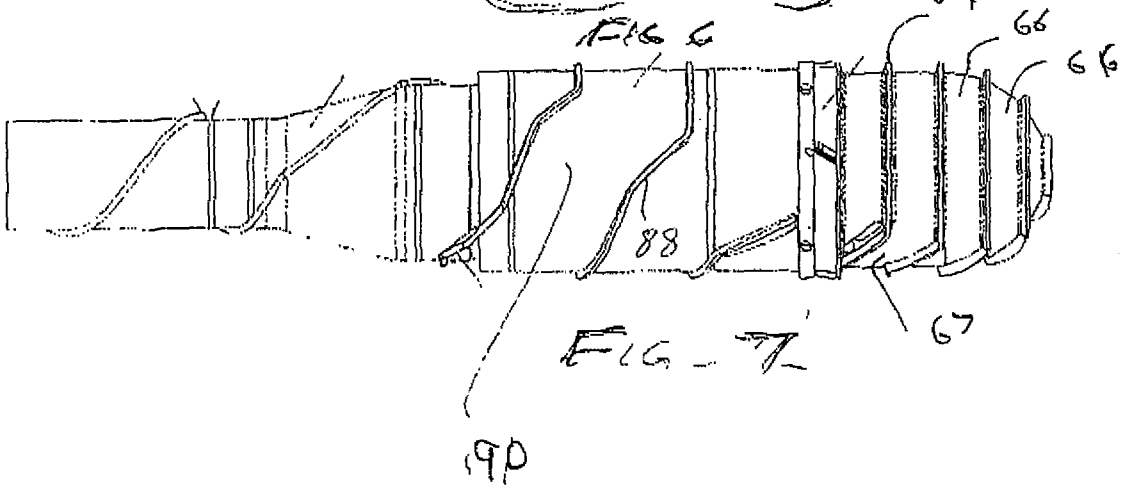

FIG. 7

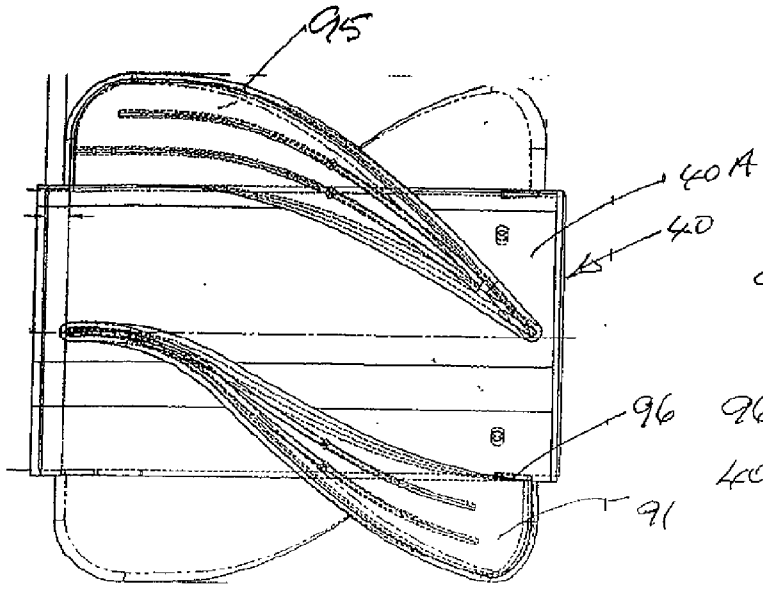

FIG_9_

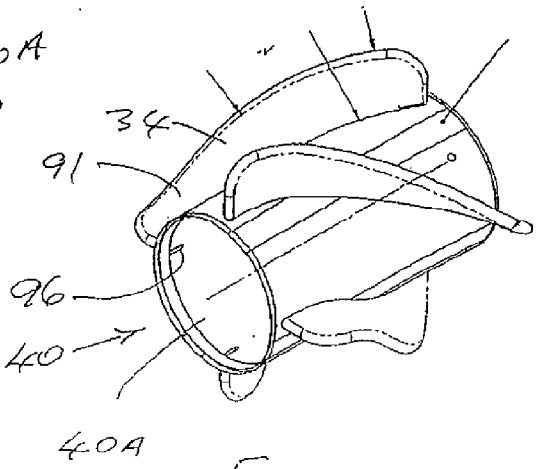

FIG_8_

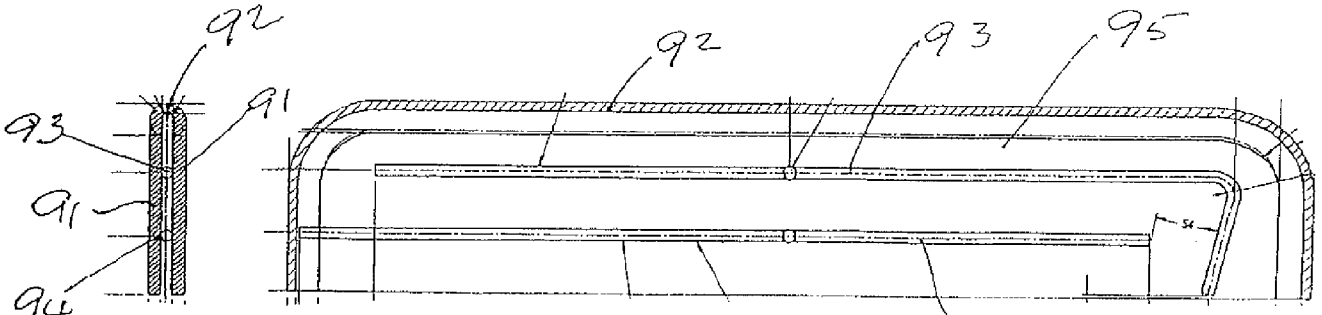

FIG_11

FIG_10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/001606

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C21C 5/46 (2006.01) *C21C 7/00* (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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)
WPI, EPODOC – IPC C21C 5/46, C21C 5/56, C21C 7/00, C21C 5/30, C21B 13/00, C21B 5/00, F27D 3/16, C22B 9/05, F27B 1/20, F27B 3/18 & Keywords (LANC+ OR INJECT+, VANE? OR BLADE? OR FLIGHT? OR FLUTE? OR RIB?, SWIRL+ OR THREAD+ OR VORTEX OR HELICAL OR HELICE+ OR SPIRAL+ OR SCREW+ OR TWIST+)

WPI, EPODOC & Keywords (LANC+ OR INJECT+, VANE? OR BLADE? OR FLIGHT? OR FLUTE? OR RIB?, SWIRL+ OR THREAD+ OR VORTEX OR HELICAL OR HELICE+ OR SPIRAL+ OR SCREW+ OR TWIST+, GAS, COOL+)

GOOGLE PATENTS & Keywords (GAS, LANCE, NOZZLE, VANE, SWIRL, COOL)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1942200 A2 (TECHNOLOGICAL RESOURCES PTY. LTD [AU]) 9 July 2008 see abstract; claim 1; figures 1 – 3	
A	EP 1939306 A2 (TECHNOLOGICAL RESOURCES PTY. LTD [AU]) 2 July 2008 see abstract; claim 1; figures 1 – 3	
A	EP 1932927 A2 (TECHNOLOGICAL RESOURCES PTY. LTD [AU]) 18 June 2008 see abstract; claim 1; figures 1 – 3	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search
12 February 2010

Date of mailing of the international search report 17 FEB 2010

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/001606

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	WO 2006 / 096902 A1 (TECHNOLOGICAL RESOURCES PTY. LTD [AU]) 21 September 2006	
A	see abstract; claim 1; figures 1 – 19	
	WO 2003 / 006693 A1 (TECHNOLOGICAL RESOURCES PTY. LTD [AU]) 23 January 2003	
A	see abstract; claims 1, 8 – 9, 13 – 15, 19, 22 – 23; figures 1 – 19	
	US 2001 / 0033046 A1 (DUNNE) 25 October 2001	
A	see abstract; claim 1; figures 1 – 10	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2009/001606

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	1942200	AU	2007246208	CN	101294231	JP	2008240144
		US	2008272527				
EP	1939306	AU	2007246209	CN	101294771	JP	2008208453
		US	2008265473				
EP	1932927	AU	2007246207	CN	101408379	JP	2008190031
		US	7568681	US	2008258321		
WO	2006096902	AU	2005220280	AU	2005222497	AU	2005329362
		BR	PI0504438	BR	PI0504439	BR	PI0516495
		CN	1760378	CN	1782099	CN	101080503
		EP	1652940	EP	1652941	JP	2006112779
		JP	2006138623	RU	2005131909	RU	2005131910
		RU	2007117923	US	7481965	US	7588718
		US	2006108722	US	2006108723	US	2009014928
WO	03006693	BR	0205726	CA	2419508	CN	1464911
		CZ	20030387	EP	1404881	MX	PA03001774
		NZ	524003	US	6773659	US	2003011114
		ZA	200300856				
US	2001033046	CN	1315648	DE	10103940	JP	2001234231
		KR	20010078133	US	6440356		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX