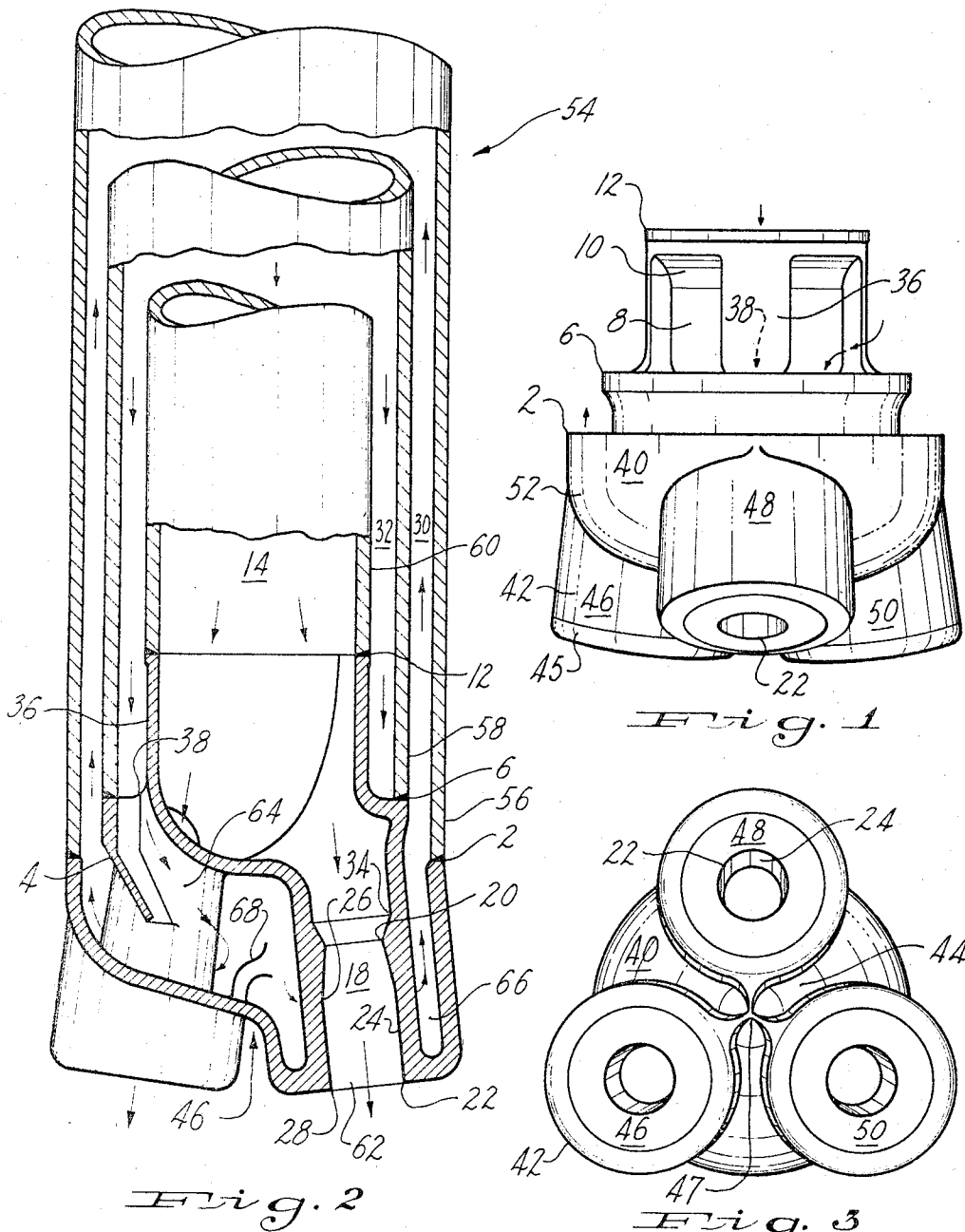


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W. V. BERRY
OXYGEN INJECTION NOZZLE WITH EXTERNALLY
PROJECTING CONDUITS
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INVENTOR
WALTER V. BERRY

BY *Green McCallister*
and Miller
ATTORNEYS

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OXYGEN INJECTION NOZZLE WITH EXTERNALLY PROJECTING CONDUITS

Walter V. Berry, Pittsburgh, Pa., assignor to Berry Metal Company, Harmony, Pa., a corporation of Nevada

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ABSTRACT OF THE DISCLOSURE

An oxygen injection nozzle head for forming a high temperature furnace oxygen injection lance by jointure to a shank having concentric fluid-conducting channels therein, the nozzle head having a substantially spherically curved oxygen-ejecting face with a plurality of water cooled oxygen-emission passageways with wall portions thereof projecting beyond the face surface and defining an intermediate space therebetween, said passageways opening as ports, at least a portion of each of said wall portions being of double-walled thickness to provide an internal fluid-flow cavity therein and adjacent to each of said passageways.

This invention pertains generally to injection lances for use in high temperature furnaces, and more particularly to an improved injection lance nozzle that will deliver a sustained high quality performance while withstanding the rigorous environmental conditions common to all types of furnaces used in the basic metal industries.

In accordance with the prior art, of which I am aware, extensive improvement has been made in recent years in the process of steel making, and of particular importance has been the increase in productive capacity of furnaces due to the introduction of oxygen directly onto the molten bath within the furnaces. Various types of injection lances have been developed to introduce the oxygen into the furnace, and the extensive benefits obtained through the use of injection lances has fostered considerable experimentation to improve their operational effectiveness. The end of the lance, commonly referred to as the nozzle, has received considerable past attention. The short history of the injection lance has been marked with much activity and many stages of development in the construction of the nozzle in the interest of improving its function and extending its life.

My invention, Patent No. 3,043,577, is only one of many examples of the work that I have done in this area to improve the construction of injection lances. My work, like that of others in the art, has produced many answers to the demand of the basic metal industries for increased yield at less expense. However, in spite of the much improved lances that have been introduced into the art, I have concluded that furnace operators are nevertheless badly in need of an improved lance for the attainment of new thresholds of efficiency and economy. My most recent research and exhaustive experimentation has led to the invention of a novel compound nozzle for an injection lance, which because of the unique concepts embodied in its construction will provide furnace operators with a means to reach a new plateau in their quest for a higher yield at lower cost. The development of the novel characteristics contained in the construction of my present invention was originally sparked by my observation of certain shortcomings in nozzles of the prior art.

I had noticed that such nozzles suffered extreme deterioration due to particles ejected from the bath. I had also observed that there is a need for a method of con-

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trolling either the constant high velocity direction of particles or its damaging effect to the exterior surface of the nozzle. I had further concluded that if possible such control must be achieved through radical changes in the construction of the nozzle itself. A further observation of mine concerned the effect of the extreme high temperature environment on the body of the nozzle. Softening of the base metal and subsequent distortion of the nozzle is a constant problem.

The tendency for compound or multiorifice nozzles to cause, because of their design and construction, the creation of a vacuum core in the central region between the oxygen streams as they are emitted from the nozzle is another problem I have recognized. Natural forces cause a tendency to fill the vacuum, and furnace gases with entrained particles tend to move through and between the emitting oxygen streams. The effect of the intruding gases on the oxygen streams is to cause turbulence, distortion, diffusion and dilution. Accompanying variations of pressure in and around the streams caused by the central vacuum results in oscillation in speed and in direction of the streams. This directional oscillation of the streams becomes an oscillation in effective force of the streams and is transmitted to the bath in the form of oscillating pressures on the bath. The oscillating actions of the oxygen jets thereby produce lance damage caused by slopping, sparking, and excessive splashing and ejection of particles back toward the nozzle, as well as damage to the walls of the vessel.

Generally, the major improvements that have been recognized as most vitally needed, can be categorized to three major areas: (1) damage to the nozzle from the molten bath, (2) poor heat removal per unit area of nozzle surface, and (3) inefficient use of the oxygen being injected.

It is accordingly an object of my invention to provide a nozzle head for an oxygen lance that, by means of the reduction of tap to tap time in the operation of a reactor vessel, will greatly increase production.

It is another object of my invention to provide an oxygen injection lance nozzle head that is of prolonged operating life in a high temperature reactor vessel.

It is a further object of my invention to provide an improved lance assembly for injecting oxygen into a furnace which obtains maximum use of the oxygen and a minimum waste.

It is an ancillary object to obtain a maximum supply of oxygen in the bath with a minimum of oxygen being carried off with waste gases exhausting through the hood of the furnace.

It is also an object of my invention to provide a lance nozzle head having an increased internal cooling efficiency so as to reduce softening and distortion of the base material thereof.

An additional object of my invention is to provide a lance nozzle head which, through its unique exterior design, will substantially reduce surface deterioration.

It is a further object of my invention to provide a lance nozzle head incorporating into both its exterior surface configuration and its interior oxygen passages unique aerodynamic structural principles that will greatly improve the function of the lance and the overall efficiency of the furnace operation.

It is an ancillary object of my invention to provide a novel and useful process and apparatus for the improved refining of materials.

In accordance with my invention I provide a nozzle for an injection lance assembly which contributes to the art by the unique solution of the problems previously outlined. First, the nozzle is only similar to the prior art nozzles to the extent that it too is of a multiorifice construction. The outer configuration of my nozzle is radical-

ly changed, leaving further resemblance between it and the nozzles preceding it in the art, one strictly of function and purpose rather than appearance. Instead of the conventional arrangement of oxygen ports emitting from the smooth face of the nozzle, my invention introduces a nozzle with its end surface divided into a plurality of faces, so that the oxygen ports no longer open from a common surface face. In the preferred embodiment of my invention the face of the nozzle is trifurcated so that each of these three oxygen channels extends outward beyond the main body of the face of the nozzle and is housed in its own separate appendage. This departure from a conventional construction results in an ejection lance whose furthest end extensions appear to consist of multi-nozzles, each housing its own oxygen channel having a separate orifice therein. This multinozzle type of construction allows for a novel lance surface treatment that imparts numerous advantages.

The tendency of the downward rushing oxygen streams to create the vacuum in their midst can be beneficially compensated for so as to materially reduce the aforementioned adverse effects. The pathways for furnace gases moving in between each of the separate nozzles and its adjacent nozzle is sloped so as to be aerodynamically contoured inwardly and down toward the direction of the molten bath so that all such pathways at their points of origin are higher and substantially further from a bath than the oxygen emitting ports. These contoured pathways between the separate nozzles slope inwardly and down to a common point coinciding with the vertical axis of the lance. Furnace gases will no longer pass through and between the oxygen streams as they are drawn into the vacuum core, but are drawn in above the emerging oxygen streams and are fed down into the bath as a united stream that becomes coextensive with the circumambient oxygen flow. The controlled motion of the flow of furnace gases across the face of the lance and down through the central core assures minimal distortion and minimal fragmentational damage, thus increasing the life expectancy of the lance. The controlled flow of gases also serves to increase the efficiency of the operation, since dilution, oscillation, and distortion of the oxygen streams are considerably reduced. In addition this provides a smooth and simple process for oxidizing some of the carbon monoxide in the atmosphere above the bath so as to produce cleaner waste.

In accordance with my invention I provide a novel system of water cooling so as to increase the lance life; improved external coating and configuration cooperating therewith for protecting the nozzle; and a novel configuration for the oxygen channels which prevents "pumping" by the oxygen stream and cooperating with the exterior design of the lance produces a lance which substantially eliminates the problems of pounding or oscillation of the bath which is frequently caused by high velocity oxygen blowing.

The important features that I consider characteristic of my invention are set forth in detail in the appended claims. However, the construction and function of the invention, together with additional associated objects and advantages will be best understood from the following detailed description when read in connection with the accompanying drawings in which:

FIGURE 1 is a side view of the lance head shown prior to its attachment to the shank of the injection lance.

FIGURE 2 is a side view of the entire oxygen lance assembly, shown with its outer surface and interior channel walls partially cut away.

FIGURE 3 is an end view of the head or nozzle portion of the lance in accordance with the preferred embodiment of my invention.

In accordance with my invention I provide a compound nozzle head for a lance for the purpose of injecting fluid materials such as oxygen into a steel furnace in

which the lance protrudes through the top of the furnace and extends down into the interior thereof to a point preferably about six feet above the surface of the materials being treated therein.

Considered separately, the head of the lance as shown in FIGURE 1 has three annular shoulders 2, 6, and 12 located at higher horizontal levels respectively, with their relative diameters diminishing in the same order. The upper portion of the lance head beginning at the shoulder 2 with the greatest diameter, which is on the lowest horizontal level, is in the form of a combination male and abutting insert to be fitted into and against the female or receiving end of the lance shank to form a fully assembled lance as shown in FIGURE 2. Each of the aforementioned shoulders 2, 6, and 12, at final assembly, is welded to a corresponding channel wall 56, 58, and 60 in the lance shank 54. The transverse welds shown at 2, 6, and 12 in FIGURE 2, join the shoulders of the head to the annular walls of the shank 54, sealing and completing the formation of three vertical, coaxial channels 14, 30, and 32, in the final assembly. The three coaxial channels 14, 30, and 32 lead from the shank 54 and into the head; and are the central oxygen tube 14, the incoming water channel 32 which is immediately circumjacent the central oxygen tube 14, and the outer coolant return channel 30 which is an annulus contained just within the wall 56 of the final assembly shown by FIGURE 2.

In the preferred embodiment of my invention the diameter of the central oxygen tube 14 at the point 12 where it enters the nozzle head from the shank 54 is approximately equal to two-thirds of the total diameter of the lance shank 54. As this central oxygen tube 14 extends down into the head, it separates into three tributary tubes, one of which is shown by 18, FIGURE 2, which, in the embodiment shown, diverge from the vertical axis of the lance 54, each at an angle of approximately 10°. It should be emphasized that other embodiments contemplated within the scope of this invention may have tributary oxygen tubes such as 18 branching from the central oxygen tube 14 wherein the angle of the branch tubes in relation to the vertical axis of the lance 54 may fall anywhere within a range of 6 to 18°.

Considering now the tributary tube 18 revealed in the drawing in FIGURE 2, it will be seen that the internal configuration therein is a converging-diverging nozzle. Each of the tributary tubes is machined to have an identical internal configuration as shown in this example 18.

Beginning at the point 34 where the annular wall of the tube 18 begins to converge inwardly, and moving toward the exit port 62 of the tube to the throat 20 where the convergence of the annular wall ends, this portion of the nozzle can be described as an embodiment of the DeLaval nozzle, as first documented by the Swedish engineer, DeLaval. The diverging motion of the nozzle from 20 to 26 in one embodiment of my invention, is a curved wall formed by striking an arc from a point or a plane through the axis of the oxygen conduit 18 so that said diverging portion on a line from 20 to 26 is conical, with its surface wall slightly curved between the points 20 and 26. From the point at 26 of greatest divergence, downward to the end of the nozzle at 62 is a cylindrical portion 24 approximating in length the length of the converging-diverging portion which is from 34 to 26.

In regard to the cylindrical extended portion of the nozzle, it should be emphasized that it has a twofold purpose. M. S. Kisenko, in his "Comparative Results of Tests of Several Different Types of Nozzles," NACA TM, 1066, June 1944, concludes that a nozzle with a conical divergence which ends with a cylindrical portion gives a better velocity distribution than a conventional DeLaval nozzle. His observation has proved to be correct. However, the cylindrical portion shown at 24 is of a longer length than is necessary to satisfy Kisenko's theory. The improved velocity distribution available by

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use of an additional cylindrical portion is not directly dependent upon the length of the cylindrical portion. Additional length is provided herein in order to perform a second function. Experience has shown that the edge 22 around the port 62 will, over a period of time, begin to oxidize due to the presence of the oxygen flow in contact with the high temperature surface of the structure. This reaction on the edge of the port is anticipated, and a long length cylindrical bore preceding the port exit 62 is provided so that material erosion due to the aforementioned reaction will not interfere with the primary purpose of the cylindrical bore. Although use over a long period may result in the edge 22 of the emitting port 62 taking on the configuration of a shallow flare, there will always remain a substantial portion of the cylindrical portion 24 to continue the aforementioned effect, as described by Kisenko.

Referring now to the lance portion 54 of the assembly shown in FIGURE 2, completely surrounding the central oxygen tube 14 is an annulus that is a channel 32 for incoming liquid coolant. Coolant flowing down through this annular passage 32, at a point just below the welded shoulder 12, is separated into three separate inwardly leading channels as shown at 8, FIGURE 1. This separation is caused by the presence of the outer walls as shown in FIGURE 1, numeral 36 of the tributarial oxygen tubes 18. Thus the incoming annular flow is split into three streams, each of which is guided by an apron 4, FIGURE 2, which is the continuation of the outer channel wall 58, so that the incoming water flow is directed to cascade down and around the outer wall 64 of the tributarial oxygen tubes so as to completely fill and circulate about the furthest extension of the water jackets 66 that surround the oxygen tubes. Having completely circled and inundated the lower extension of the annular passage 66 around each of the tributarial oxygen tubes 18, the water then flows up the return channel 30 which in the assembled lance is an annulus whose outer wall coincides with the outer wall 56 of the assembled lance.

Considering now the exterior configuration of the face of the nozzle head (FIGURES 1 and 3), the nozzle head is provided with a base portion 40 that is a spherically shaped face and protruding therefrom in a cloverleaf design is a plurality of facial extensions 46, 48, and 50, which are called conduits, having in the center of their respective faces the jet-emitting ports as at 62. It will be observed that between each two protruding, thick walled conduits, as between 46 and 48, there exists a portion 44 of the main spherical face 40 of the nozzle such that there are three sloping channels or pathways 44, each beginning near the outer edge of the spherical face at 52 and sloping over the surface 40 of the face to converge with the other two pathways at a point 47 which is the center of the spherical face. Said conduits 46, 48 and 50 are spaced apart a distance such that the open spaces or pathways 44 exceed or equal the cross sectional area of each orifice 22.

Having generally pointed out the structural formation of the nozzle head, an explanation with reference to the accompanying drawing, of its operational function within a reactant vessel will more clearly depict the salient novel characteristics of the invention.

First of all, the instant invention is technically superior to conventional nozzle heads in that it will virtually eliminate a major problem previously encountered when the emitting oxygen jets were diluted and oscillated by the waste gases of combustion. The purpose of the converging-diverging nozzle 18 previously described is to create a jet flow with a velocity in the range of Mach 1.5 or above which will emit from the oxygen port 62 and continue to the bath below as a laminar flow.

In prior nozzles the emitting oxygen jet has a core wherein the flow is laminar, with a surrounding turbulent boundary layer. Following now the downward motion of

the jet in that type of nozzle, the boundary layer increases in thickness and the core diameter decreases until it disappears. At the point of disappearance the flow is then fully turbulent. The improved construction of the instant invention, particularly the internal nozzle 18 construction, effectively delivers a jet flow the diameter of which is comparable in flow characteristics to the core region in the flow emitting from conventional nozzles. It is my conception that two cooperating principles embodied in the compound-nozzle head make possible the sustained laminar flow along the entire length of the jet from the nozzle head to the bath.

If two or more jets are at close distance each jet is partly shielding the others from the inflow of carbon monoxide; this inflow becomes asymmetric with respect to the centerline of each jet and the pressure distribution on the jet boundary is also asymmetric. By Coanda effect the jets tend to bunch together and to stay locked in this position at some distance below the nozzle exit.

The environmental conditions in a basic oxygen furnace can be simply described as a cold stream of oxygen jetting downward into a large vessel through an area filled with high temperature waste gases flowing in an upward direction. So, having established a superior method of delivering the oxygen streams toward the bath in a supersonic, laminar flow, subsequent control of the physical interaction of the waste gases with the oxygen streams through which the gases must penetrate will further enhance the efficiency of the compound-nozzle head. In any multiorifice nozzle there exists a vacuum, or low pressure region between the onrushing streams of oxygen. Waste gases, including carbon monoxide, rush through and between the oxygen streams to relieve the low pressure condition therein and has the adverse effects of distorting the oxygen's streams, intermixing and pulling them together with a resulting turbulence, then creating oscillation in the streams which is transmitted then to the bath. These effects heavily contribute to refractory and lance damage caused by resultant sparking and slopping. In the compound-nozzle head the carbon monoxide is directionally controlled to dissipate the aforementioned adverse effects. By extending each nozzle 18 in its own separate housing (such as 45), entrances are provided between each of the two protruding conduits, as at 44. The carbon monoxide rushes to relieve the vacuum between the down rushing streams along the contoured pathways 44 over the face of the base portion 40 of the compound-nozzle head. The gases of combustion will enter and combine as a centrally flowing core in an area above and behind the emitting oxygen jets 62. The pathways 44 converging across the face of the base portion 40 of the compound-nozzle head present sloping surfaces profiled to feed the inrushing gases so that the three separated flows of inrushing gases unite as a solid stream at 47. The inwardly sloping pathways 44 also provide a means of reducing the adverse effect which is familiar in the prior art, when molten particles or slag ejected from the bath strike the lance face. With the compound-nozzle head, particles that may reach the vicinity of pathways 44 will impact at an oblique angle to the surface. Thus, the contoured surface will encourage the particles to ricochet rather than entrain thereon.

Inasmuch as care has been taken to profile the facial surface of the entire compound-nozzle head for the functional purposes previously described, attention is directed to the possibility of coating or inlaying selected portions of the facial surface (FIGURE 3) which includes the base portion 40 with the projecting conduits 46, 48, and 50. The careful blending of all surfaces where they adjoin, by a gradual sloping, would be conducive to adherence of a case material applied by a coating process. It may be found practical to undercut portions of the facial surface, and affix refractory materials or a selected alloy thereto. The presence of the secondary layer of material affixed to the facial surface of the compound-nozzle head

would be to protect the head itself by encouraging the flow of gases in the direction of the contours 44, or by changing the rate of heat transference to the nozzle head, or by inhibiting the erosion of the facial surface due to particle impact. It is expressly stipulated that the application of a secondary layer of a coating material as previously described may be found desirable. The future application of such material is herein expressly anticipated and included within the scope of the invention.

An optional feature available in the instant invention has to do with the possibility of using the lance assembly as herein described with coolant flow flowing in a reverse direction; that is, having the incoming coolant flowing through what is now the exit channel 30 and using the coolant channel 32 nearest the central oxygen tube 14 as the exit channel. A reversed coolant flow direction may be found desirable in actual use or in future experimentation, depending perhaps upon the nature of the site of operation, the desired distance of the lance end above the bath, etc. However, referring now only to the direction of the flow established by the arrows in the drawing, it will be seen that the incoming water flow through the channel 32 in the lance shank 54 is directed in a straight, downward flow which completely surrounds the central oxygen tube 14. The low temperature within the oxygen tube 14 will have the incidental effect of cooling the wall 60 of the tube 14 and thus will conduct heat away from the liquid within the channel 32. In this manner the liquid coolant along the entire length of the shank 54 as it moves down the channel 32 is cooled sufficiently to offset any heat transference from the outer wall 58 of the channel 32, said outer wall 58 being shared with the exit channel 30. For this reason the above described direction of coolant flow is considered the more desirable.

However, it is understood that in accordance with other embodiments of my invention the flow of coolant may be reversed and produce better flow characteristics in the nozzle although at the expense of employing a warmer coolant at the nozzle.

It should be emphasized that coolant flow is maintained, both incoming and outgoing, at a rapid vertical streamline flow within the lance shank 54. At the point (as at 38) within the compound-nozzle head where the incoming flow is split into three separate streams, the structural wall 10 is inwardly contoured to continue an unobstructed flow. Turbulence in the coolant flow to assure a scrubbing action to remove steam bubbles or air pockets on the surfaces of the coolant passage 66 is introduced when the incoming coolant, after having been directed down and around the outer walls of the oxygen tubes, smashes into the ridge-like separations at 68, which are the inside surfaces of the outer contoured passageways 44 previously described. These ridges 68 formed on the inside surface of the base portion 40 act as deflectors to split the merging coolant flow and guide the coolant to the extreme ends of the jacket passages 66.

It will be noted from the drawing and the foregoing description that the projecting conduits which are themselves water cooled, tend to protect the region therebetween from excessive radiation. For example, the bottom portion of the groove between adjacent projecting conduits can only receive radiation coming from a region of the bath through an angle of about 10 or 15°. Radiation from other sections of the bath cannot reach the bottom of this groove or canyon because the bottom portion is shielded by the adjacent protruding conduits. Thus, by the configuration which I employ radiation damage in the region near the center of the lance is effectively eliminated.

Other embodiments within the scope of this invention are contemplated. One example would be the inclusion in the assembly as here described of a vertical, axial pipe which would have one end beginning in the center at 47 of the base portion 40 of the compound-nozzle head. The opening of the pipe would be of a small enough diameter

not to interfere with the purpose of the contoured pathways 44 across the face of the base portion 40 of the head. This pipe would extend in such a manner that its axis would coincide with the axis of the lance shank 54. Such a pipe, if included in the structure, might lend itself to a variety of uses: it might be employed as a means of viewing the bath directly from above; it might be used as a central passage through which to obtain gas samples; or it might be employed as a passage through which to extend a thermocouple to gauge the temperature of the bath, or to inject additional ingredients into the furnace.

There is an upper limit to the relative particle velocity which any material can sustain upon impact. When this limiting value is exceeded the material parts in a brittle manner. This limiting value is called the critical relative particle velocity of the material and is related to a critical dynamic fraction strength. The limiting velocity is normally taken to be the same as the experimentally determined critical impact velocity of the material. For copper the theoretical critical velocity is 260 feet per second and the experimental critical velocity is 200 feet per second. Thus in accordance with one embodiment of my invention the size of the region between projecting conduits may be defined as that size aperture through which an adequate supply of gas may pass to fill the vacuum created by the oxygen jets without causing that gas to exceed a velocity of 200 feet per second as it approaches the axis of the lance. This definition is, of course, based on the assumption that the particles are effectively entrained by the gas and therefore the velocity of the particles will be substantially equal to the velocity of the gas. This conception may better be understood by those unfamiliar with the terminology involved by reference to the publication "The High Velocity Forming of Metals," published by the ASTM with particular reference to the discussions around page 27.

While I have emphasized herein a compound nozzle having three nozzles, nevertheless, it is understood that four or more nozzles might be employed in forming a compound-nozzle head. It is also understood that while I have shown the throat to comprise a single annular line, nevertheless, in accordance with other embodiments of my invention, the throat may be of finite width, e.g., the throat of each nozzle may comprise a short section of cylindrical shape.

Although I have shown and described specific embodiments of my invention, I am fully aware that other modifications thereof are possible and may eventually be desirable. The invention therefore is not to be restricted except insofar as is necessitated by the prior art.

I claim as my invention:

1. A compound nozzle head for forming an oxygen injection lance by its jointure to a shank having concentric fluid-conducting channels therein, said nozzle head comprising a substantially spherically curved face having a plurality of material ejection conduits protruding therefrom, the ends of said conduits opening as ports having respectively therearound wall portions projecting beyond said face and defining therebetween an intermediate space, each of said wall portions of said conduits having passageways for water cooling and protruding a distance approximately equal to the diameter of each of the ports of said ejection conduits as measured along their sides nearest the axis of said nozzle.

2. An oxygen lance compound nozzle head to be affixed to a shank to form an oxygen lance made to project down into a furnace, said nozzle head being cored to receive a fluid coolant flow from said shank, said nozzles head having internal passageways to accommodate said coolant flow from said shank, through said nozzle head and back through said shank, said nozzle having a central internal oxygen conduit to conduct a downward oxygen flow from an interconnecting conduit in said shank, said nozzle head having an outer geometrically solid

spherical configuration forming a base portion having extended therefrom a plurality of identically shaped water cooled nodular heads, said heads housing the exit ports for said downward oxygen flow.

3. An oxygen lance compound nozzle for injecting combustion materials into a high temperature furnace comprising a geometrically solid spherically curved face having protruding therefrom a plurality of material ejection conduits, said conduits being water cooled and protruding a distance approximately equal to the diameter of the exit openings of the ejection conduits, as measured along the sides of the conduits nearest the axis of said nozzle.

4. A compound nozzle head for injecting oxygen into a steel furnace comprising a substantially spherically curved face having protruding therefrom a plurality of material ejection conduits, said conduits having passageways for water cooling and being spaced apart a distance such that the open space defined by the face of the nozzle, adjacent conduits, and a line between their exit openings exceeds the cross sectional area of each of the orifices.

5. A compound nozzle head for injecting oxygen into a steel furnace comprising a substantially spherically curved face having protruding therefrom a plurality of material ejection conduits, said conduits having passageways for water cooling and being spaced apart a distance such that the open space defined by the face of the nozzle, adjacent conduits, and a line between their exit openings is substantially equal to the cross sectional area of each of the orifices.

6. A compound nozzle head for an oxygen lance comprising a geometrically-solid configuration in the form of a base portion with a plurality of nodular heads housing oxygen passages the rethrough leading to respective oxygen exit ports, and a coolant flow region around the oxygen passages, said heads protruding from said base portion.

7. A compound nozzle head for injecting oxygen into a steel furnace comprising a substantially spherically curved face having protruding therefrom a plurality of material ejection conduits, said conduits having passageways for water cooling and being spaced apart a distance such that the open space defined by the outer walls of adjacent conduits, the face of the nozzle and a line between their exit orifices exceeds the cross sectional area of the orifices, and said conduits comprising double walls spaced apart for circulation of coolant therethrough.

8. An oxygen lance compound nozzle to be affixed to a shank to form an oxygen lance made to project down into a furnace, said nozzle having internal passageways to accommodate coolant flow from said shank, through said nozzle, and back to said shank, said nozzle having a central internal oxygen conduit to conduct a downward oxygen flow from an interconnecting conduit in said shank, said nozzle having a geometrically solid substantially spherically shaped face with a plurality of identically shaped water cooled nodular heads extending therefrom, said heads housing the exit ports for said downward oxygen flow.

9. An oxygen lance nozzle as described in claim 2 having an ancillary open end axial passage extending from the midpoint of said spherical base portion vertically along the axis of said nozzle to an interconnecting passage provided in said shank, said axial passage contained for its full length by a cylindrical wall, said passage extending from said spherical base portion and up through and co-extensive to said central oxygen conduit.

10. In an oxygen lance for feeding oxygen into a reactor vessel, an oxygen lance compound geometrically solid spherically shaped nozzle head having an emitting end portion comprising a base portion with a plurality of protruding water cooled conduits, each of said conduits having a central coextensive oxygen emitting tube, said tube including a portion having an internal configuration of a converging-diverging jet nozzle.

11. Apparatus as described in claim 10 in which said tube extends beyond said converging-diverging nozzle as a cylindrical bore ending as a jet emission port on the face of said conduit.

12. Apparatus as described in claim 11, characterized by said cylindrical bore and said conduit through which said bore extends being projected to a length wherein the length of said cylindrical bore is greater than the length of said converging-diverging nozzle.

13. An oxygen lance nozzle for injecting oxygen into a steel furnace comprising a geometrically solid spherically curved face having protruding therefrom a plurality of material injection conduits, said conduits being spaced apart a distance such that the open space defined by the face of the nozzle, adjacent conduits, and a line between their exit openings exceeds the area of each of the orifices of said conduits, said spherically curved face having its surface regions joined by contoured surface portions so that none of the regions of the surface thereon are sharply delineated, said spherically curved face having portions thereof with a thin heat resistant layer.

14. An oxygen lance nozzle for injecting oxygen into a steel furnace comprising a geometrically solid spherically curved face having protruding therefrom a plurality of material injection conduits, said conduits being spaced apart a distance such that the open space defined by the face of the nozzle, adjacent conduits, and a line between their exit openings is substantially equal to the area of each of the orifices of said conduits, said spherically curved face having its surface regions joined by contoured surface portions so that none of the regions of the surface thereon are sharply delineated, said spherically curved face having portions thereof with a thin layer of reflective, abrasion-resistant material.

15. The oxygen lance compound nozzle recited in claim 2, further comprising a plurality of external contoured pathways for inducing the formation of a central vacuum core in a space centrally defined by said plurality of nodular heads, each of said pathways defined by the surface of said base portion and wall portions of adjacent nodular heads.

16. An oxygen lance compound nozzle head joined to a shank to form an oxygen injection lance with said head extended toward a molten bath within a furnace, said head cored to receive a fluid coolant flow from said shank, a plurality of internal passageways within said head to accommodate said coolant flow from said shank through said nozzle head and back to said shank, said head having a central internal oxygen distribution conduit for conducting a downward oxygen flow from an internal interconnecting conduit within said shank, said head having a base portion with a substantially geometrically solid spherically curved face, a plurality of identically shaped water cooled nodular projections on said face, each of said projections having an axial passageway opening as an oxygen port centrally on the outer end thereof, the axis of each said projections diverging at an angular relationship to the axis of said shank, each two adjacent projections having therebetween a contoured pathway formed by the face of said base portion and surface portions of said projections for conducting circumbient gases rising from said molten bath in a direction toward an extension of the longitudinal axis of said lance.

17. A compound nozzle head for forming an oxygen injection lance by its jointure to a shank having concentric fluid-conducting channels therein, said nozzle head comprising an oxygen-ejecting face that is substantially spherically curved, with said face having a plurality of oxygen-emission passageways provided therein, the ends of said passageways, opening as ports having respectively the rearward wall portions projecting beyond the level of said face and defining therebetween an intermediate space, each of said wall portions having at least a portion thereof of double-walled thickness to provide an internal fluid-

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flow cavity therein and adjacent to each of said passageways.

18. An oxygen injection nozzle head for forming a high temperature furnace oxygen injection lance by jointure to a shank having concentric fluid-conducting channels therein, said nozzle head having a substantially spherically curved face with a plurality of water-cooled oxygen-emission passageways opening as ports, wall portions about said passageways and said ports, said wall portions projecting beyond said nozzle head face and defining an intermediate space therebetween, at least a portion of each of said wall portions being of double-walled thickness, whereby there is provided an internal fluid-flow

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cavity in at least a portion of each of said wall portions adjacent to each of said passageways.

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J. SPENCER OVERHOLSER, *Primary Examiner*.

E. MAR, *Assistant Examiner*.

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