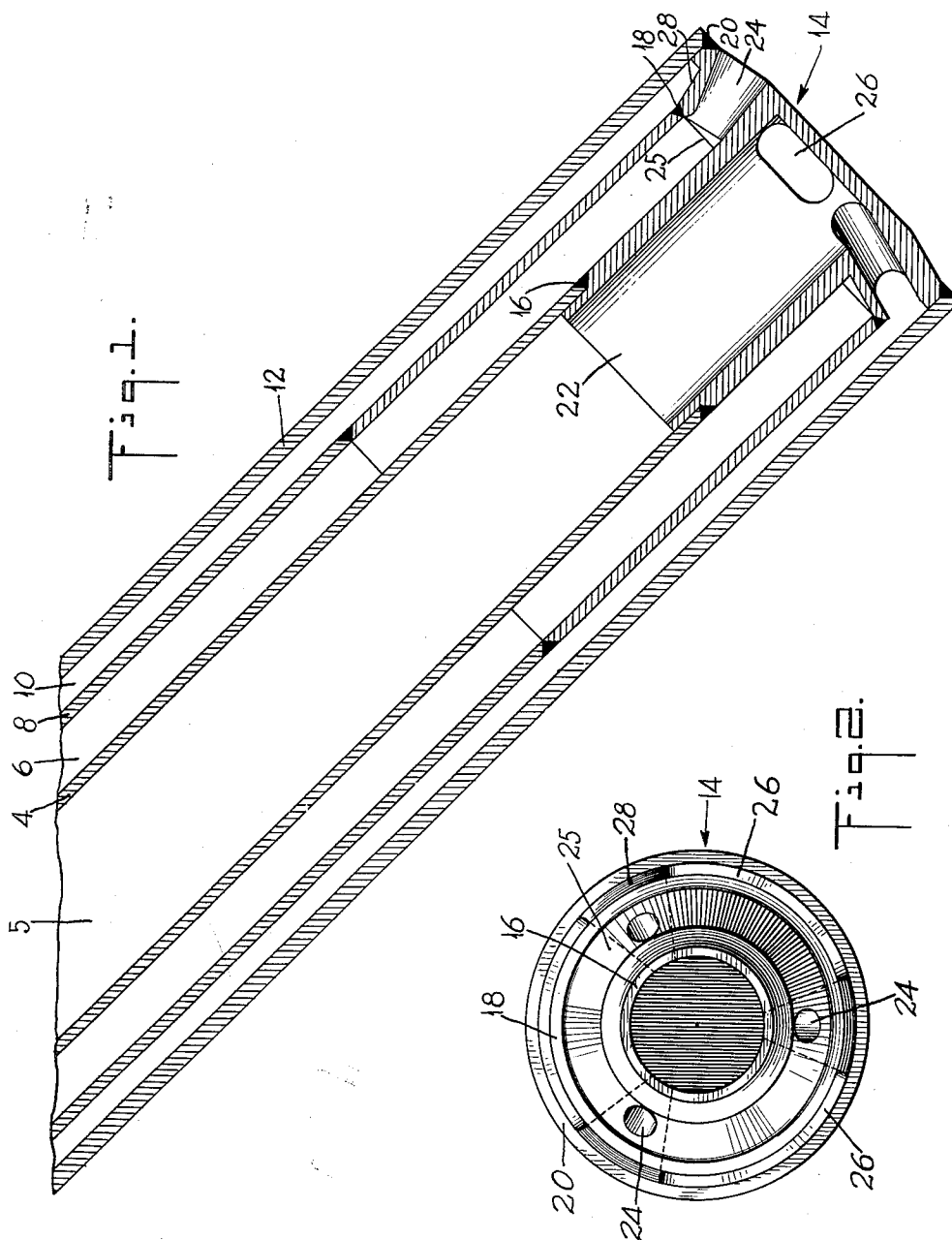


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3,020,035

3 Sheets-Sheet 1



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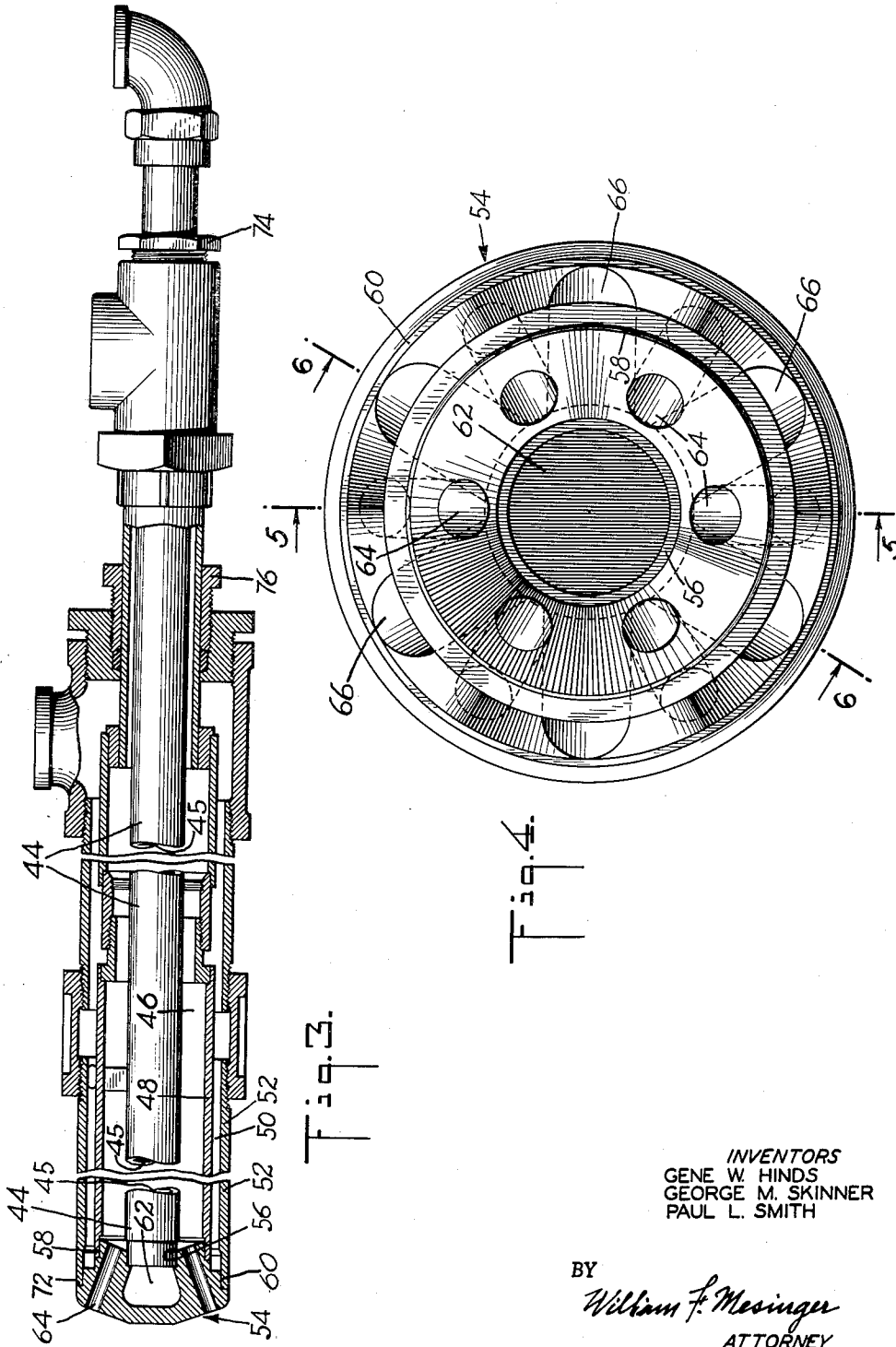
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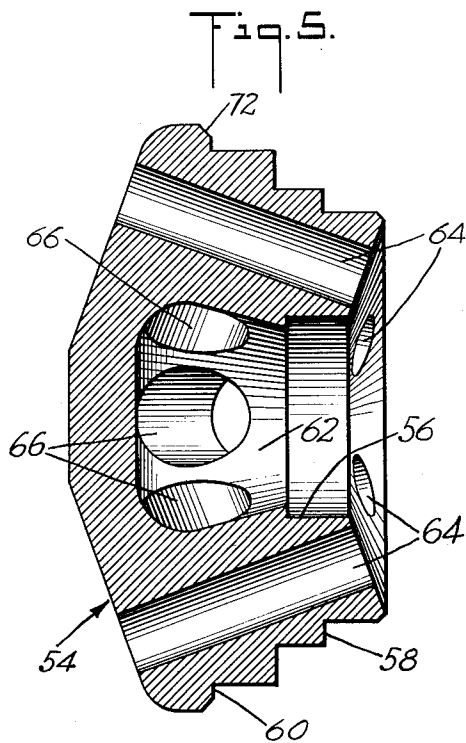
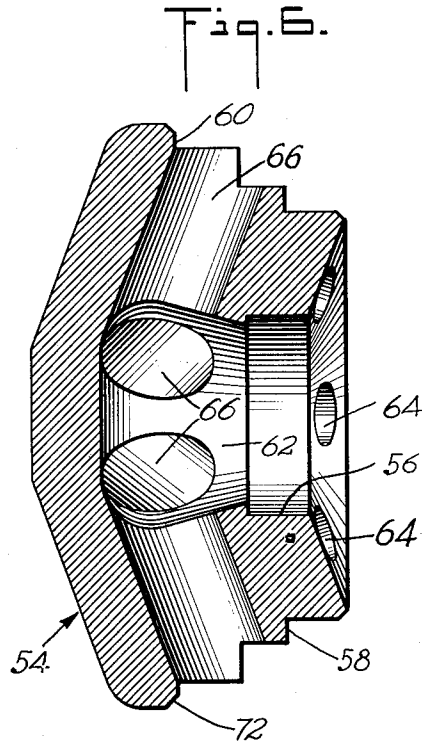
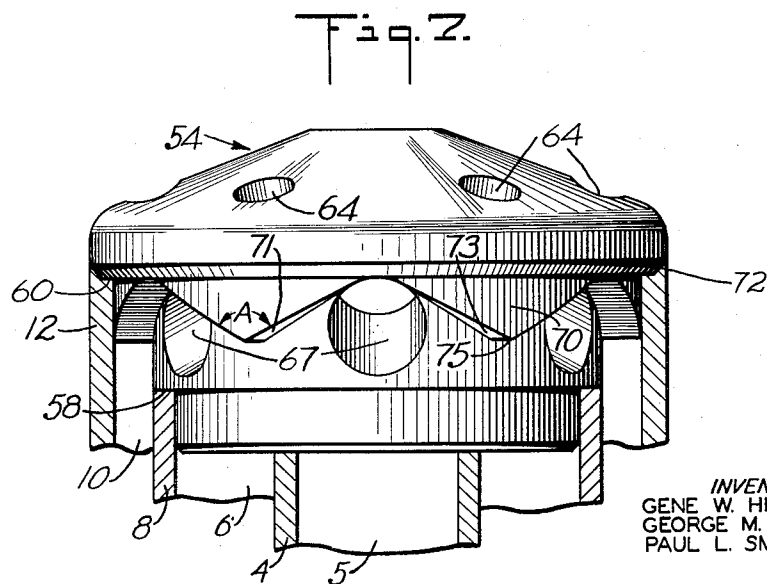
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3,020,035

OXYGEN ROOF JET DEVICE

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2 Claims. (Cl. 266—34)

This invention relates to an improved jet device for the introduction of a treating gas into a vessel containing a molten material. More particularly, it relates to an oxygen roof jet device having improved oxygen dispersion and cooling characteristics.

The use of oxygen by the steel industry to speed up production is increasing every year. Not only is oxygen used extensively in the final stages of the open hearth heat to refine the steel, but also in the initial stages to speed up the melting of scrap charges by flame enrichment with oxygen. Oxygen top blowing has been used for decarbonization, desiliconization, etc. in refractory lined vessels containing molten iron or steel. An important step forward in this development has been the adoption of the oxygen top blowing technique in the open hearth furnace, whereby oxygen is introduced into the furnace by oxygen jet devices inserted through the furnace roof. The use of this technique has made the introduction of oxygen into the open hearth furnace a practical operation by eliminating the interference with shop routine and transportation of charging materials inherent in the use of a consumable oxygen lance or water-cooled jet inserted through the door or wall of the furnace. In addition, the proper application of the roof jet technique makes possible a reduction in over-all refining time, since the oxygen injection raises the bath temperature more rapidly, resulting in earlier solution of the lime and more rapid decarbonization that is possible in non-oxygen practice.

A number of jet devices, such as the one covered by U.S. Patent 2,828,956, C. E. Bieniosek et al., have been developed for insertion through the roof of the open hearth furnace through which the oxygen stream is introduced into the molten metal bath. The temperature generated at the reaction zone or impingement point of the oxygen into the molten metal bath is approximately 4200° F. The top blowing technique for decarbonization has been found to be most effective when the front face of the jet device is relatively close to the bath surface. Thus, in order to have an economically acceptable useful-life span, such devices must be able to withstand the heat radiated from this reaction zone, the effects of which are most severe when the front face of the device is close to the level of the slag cover. Also a factor in determining the length of service life of these devices is the erosion from hot particles of slag and molten metal striking the nozzle or head and wearing the peripheral edge. These problems have been overcome to a certain extent by the use of deoxidized and forged copper heads, having rounded nose contours, which are water cooled by means of an internal circulating water flow. The majority of water-cooled jet devices used to-date have comprised:

(1) A single central oxygen passage, surrounded by annular or drilled cooling water "in" and "out" passages, from which oxygen is expelled as a single high velocity jet, well above sonic; or

(2) A plurality of short tubes welded and/or threaded into a water cooled head assembly to form a plurality of oxygen outlet ports. The welds attaching the tubes to the front face of the head in this latter design are subjected to the heat of the reaction zone and consequently weld failure is quite common. Also cast copper heads

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used in this design, being subject to porosity and impurities, have relatively poor heat conductivity, thus, seriously impairing the efficiency of the water cooling.

The use of a single high-velocity jet of oxygen in the top blowing process limits the maximum level of carbon that can be present in the molten metal bath when the process is initiated. Above approximately 0.45 percent carbon, the use of a single high-velocity jet of oxygen would not ordinarily be used because it results in a reaction sufficiently violent to cause a heavy spattering and splashing of highly oxidized molten iron onto the refractory walls and roof of the open hearth furnace as well as the jet head itself. The result is erosion and damage to the furnace walls and roof and, thus, more frequent replacement of the furnace lining than would otherwise be necessary.

Thus, for practical operation, apparatus limitations have caused the use of the top blowing technique to be limited to applications wherein the carbon level of the molten metal bath is relatively low. In order to employ the top blowing technique to its best advantage, therefore, a jet device design that overcomes the above problems is essential.

It is accordingly a primary object of this invention to provide an oxygen roof jet device having superior oxygen dispersion characteristics.

It is a further object to provide such a device having improved cooling with resultant increased service life.

Another object is to provide an oxygen jet having an efficiently cooled nozzle adapted to utilize high velocity streams of coolant streams for heat removal.

Other objects and advantages will be apparent by reference to the specification and drawings in which:

FIG. 1 is a cross-sectional view of a simplified embodiment of the invention;

FIG. 2 is an end view of the device of FIG. 1;

FIG. 3 is a cross-sectional view of a preferred embodiment of the invention;

FIG. 4 is a bottom view of the nozzle of FIG. 3;

FIG. 5 is a cross-section of the nozzle of FIG. 4 along line A—A;

FIG. 6 is a cross-section of the nozzle of FIG. 4 along line B—B; and

FIG. 7 is a side fragmentary view in partial cross-section of the nozzle of FIG. 4.

According to this invention there is provided a jet device which comprises a first tubular member defining therein a coolant conduit, a second tubular member surrounding the first tubular member and defining therebetween a first annular passageway for carrying a treating gas, a third tubular member surrounding the second tubular member and defining therebetween a second annular passageway for carrying coolant, a nozzle member closing one end of said tubular members adapted for insertion into a metallurgical furnace, said nozzle member having one or more gas passing orifices therethrough connecting the first annular passageway with the exterior of the nozzle, coolant passages within the nozzle and connecting the coolant conduit and the second annular passageway. Preferably the coolant passages are so disposed that at least one coolant passage passes between each adjacent pair of gas orifices, inlet means at the other end of the tubular members for supplying coolant to the coolant conduit, means for supplying a gas to the first annular passageway, and outlet means for conducting expended coolant from the second annular passageway.

The jet device of this invention not only fulfills the requirements as to the service life of the jet itself through greatly improved water cooling efficiency, but also minimizes the problems due to excessive splash. In addition, it increases the maximum carbon level that can be present

in the molten metal bath when the top blowing process is initiated.

Referring specifically to FIGS. 1 and 2 wherein like reference numerals refer to like portions of the device, there is shown a basic form of the apparatus which comprises three concentric tubular members 4, 8, and 12. A coolant supply is connected to first tubular member 4 which forms a central coolant conduit 5 in the device. An oxygen supply is connected by means of appropriate fittings such as shown in FIG. 3 to the first annular passageway 6 formed between the second tubular member 8 and the first tubular member 4. An expended coolant outlet is connected to the second annular passageway 10 formed between the third tubular member 12 and the second tubular member 8. Thus it may be seen that coolant enters the device through conduit 5 and leaves by means of the second or outer annular passageway 10, and oxygen is supplied to the device through the first annular passageway 6.

The tubular members 4, 8, and 12 are closed on one end by the respective coolant supply and exhaust and oxygen supply means and are closed on the other end by a closure or nozzle member 14. This nozzle member has shoulders 16, 18, and 20 for receiving the respective ends of the tubular members which are attached thereto by welding or brazing.

The nozzle member is preferably a suitably shaped block of a high heat conductivity metal such as copper. It will be seen that the nozzle member 14 has a large central hole or bore 22 therein which terminates short of the front face of the member 14. At the upper edge of the bore 22 is formed the shoulder 16 which receives the inner or first tubular member 4. Extending between the shoulders 16 and 18 is an annular surface 25 serving to close the first annular passageway 6. Oxygen orifices 24 extend from the surface 25 to the exterior face of the nozzle body 14. Three oxygen orifices 24 are shown in the drawing but more can be employed. A third annular surface is provided and indicated at 28 between the shoulders 18 and 20 to close the second annular passageway 10. It will be noted that this surface is located nearer the exterior face of the nozzle. Coolant passages 26 extend substantially radially from the central bore 22 to the surface 28. It may be seen by reference to FIG. 2 that there is a coolant passageway shown in broken lines between each adjacent pair of oxygen orifices.

The head or nozzle of the device shown in FIG. 3 is a preferred version of the nozzle 14 of FIGS. 1 and 2.

Referring to FIG. 3, three concentric tubes or pipes 44, 48, and 52 are provided, the center tube 44 forming the water "in" passage 45, the intermediate tube 48 forming an annular oxygen passage 46, and the outer tube 52 providing an annular water "out" passage 50. Expansion joints 74 and 76 provide for longitudinal differential expansion between tubes 48 and 52 and 44 and 48 respectively. Packing joints are shown in this embodiment; however, other means as a bellows arrangement could be used. The oxygen free, high conductivity copper head 54 is attached to the ends of the concentric tubes by step joints 56, 58, and 60 for added strength. The weld joining the head 54 to outer tube 52 is displaced from the face of the head to minimize the effects of heat and spatter. Tubes 44 and 48 may be silver soldered to head 54. Threaded joints in tubes 44, 48 and 52 permit easy replacement of the head section of the jet device.

FIGS. 4 through 7 show the head of the jet in detail. The oxygen exits from the head through a plurality of orifices 64 equally spaced around the outer edge of the tapered head as in FIG. 1. Thus, greater dispersion of the oxygen is attained than with a single oxygen jet. Also, the flow velocities through the orifices are preferable within the sonic range. Instead of one large focal point of reaction obtained with the single oxygen jet,

there are a plurality of, preferably, six less violent reaction areas. The result is greatly decreased spatter and splash of the highly oxidized molten iron and, thus, a minimum of damage to the refractory walls of the furnace and jet head. In addition, these orifices are shown angled at 20° to the center line of the head to remove the points of impingement of the oxygen streams from directly below the head face, thus diverting the spatter and reducing head erosion.

One of the most important objects of the novel cooling system is to prevent the formation of steam pockets or "hot spots" in the head. This has been successfully accomplished in the subject design by the following features. A plurality of equally spaced water passages 66, preferably six, located between the oxygen orifices 64, connect the central water inlet and annular water outlet passages. These water passages provide constant water velocity throughout the head face where the heat is most intense and thus, the cooling most critical. As a preferred example, the particular jet head design shown in FIGS. 3 through 7 provides a water velocity through the six passages, of 17.4 feet per second at a flow of 6000 g.p.h. The water velocity through the annulus 50 above the head is 10.3 f.p.s. for the same flow. In addition, positive cool water flow directly against the front face of the head is provided by the central water inlet passage 45 which terminates in chamber 62.

In accordance with the invention, and referring to FIGS. 4 and 7, outwardly radiating water passages 66 terminate at outlet ports 67 in the annular passage 10, at a point rearwardly adjacent the lower wall of said annular passage. This lower wall as shown comprises a series of rearwardly extending integral projects 70 which may be milled or shaped into the head portions in such a manner that at least one of said projections is disposed in, and occupies the peripheral interval between each adjacent pair of outlet ports 67. The generally triangular projections are preferably formed with a broad base and rearwardly tapered lateral surfaces 71 and 73, which converge at a peak 75. The projections define therebetween a plurality of channels adapted to receive streams of coolant from ports 67, which channels are rearwardly divergent to permit merging of the respective coolant streams into a single annular flow. With such a configuration, the respective coolant streams will be guided upwardly into passage 10 with a minimum amount of turbulence to provide an improved rate of heat transfer from the hot outer surfaces of tube 12.

Without the noted projections, cooling water entering passage 10 would tend to lie in a relatively static condition and foster the possible formation of a thin barrier or layer of steam along the hot inner surfaces of the jet head. Unless this layer is dispersed by a sufficiently rapid flow of coolant fluid, it has been found that the barrier greatly reduces cooling efficiency. We have found that by promoting a relatively non-turbulent flow of coolant, through this lower section of the nozzle and jet a great deal less fluid is required to adequately cool the apparatus for any given furnace condition.

As illustrated, the rearwardly tapered projections 70 define an angle A at the peak 75 such that the converging coolant streams come together smoothly and with a minimum amount of cavitation. The actual degree of angle so formed is dependent primarily on the amount of coolant utilized, and its rate of velocity through the respective channels therefor. We have found that by positioning the peak 75 near the upper edge of outlet port 67, the coolant is properly guided to eliminate any tendency toward cavitation where the streams come together, thereby achieving the desired non-turbulent flow effect.

As shown in the respective figures, it has been found that further advantages are realized by providing the head section 54 with a rearwardly tapering front face, thereby minimizing the detrimental effects of the hot, splashed metal particles. The heads shown in FIGS. 1 through 7

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in the preferred example are $4\frac{1}{2}$ inches in diameter; however, they can be made any desired diameter depending upon the application. Similarly, the size, number, and angle of the oxygen orifices can be varied within limits, depending upon the degree of dispersion and the angle of oxygen impingement desired, as long as the required efficiency of water cooling is maintained. Table I below gives dispersion angle limits possible with different sized orifices. It is to be understood that the angle mentioned is that angle an axial line through an orifice would make when extended to meet the axis of the nozzle per se.

Table I

Maximum Orifice Dia.	Minimum Angle, degrees	Maximum Angle, degrees
$\frac{5}{8}$ "	20	25
$\frac{1}{2}$ "	0	32
$\frac{3}{8}$ "	0	37
$\frac{1}{4}$ "	0	38

From the above description it can be seen that the embodiments of both FIGS. 1 and 3 utilize the common features of three concentric tubes feeding the head or nozzle portions wherein the inner tube carries the coolant water and the middle tube carries the oxidant. The coolant thus flowing down the inside of the tube has maximum cooling effect since it is insulated from the outside atmosphere by the coolant in the outlet annulus and the oxygen stream also. The high velocity stream of water striking the bottom of the hole or bore 62 and spreading out through the multiple passage provided therefor gives a degree of cooling unattainable with prior structures. This improved cooling is, of course, reflected in much longer service life of the device before replacement is necessary. Of equal importance is the multiple jet oxygen stream possible with the construction. The annular oxygen passageway ideally lends itself to the multiple orifice construction in order that a more uniform oxygen flow from each orifice may be attained. This is in contrast to a construction in which those orifices located near the center of the fluid conduit would have a greater exit velocity than those nearer the edge.

Thus, it may be seen that the subject oxygen roof jet is capable of performing in a manner not possible with prior devices. While certain configurations as the circular cross section of the device have been specifically shown and described, it is to be understood that many alternative designs are possible without departing from the spirit and scope of the tubular members. It should be further understood that the term roof jet as applied to the device refers to such a device which can be equally well utilized in either an open-hearth furnace or in a refractory lined vessel containing molten metal where oxygen refining is to be accomplished.

This application is a continuation-in-part of application Serial No. 715,731, filed February 17, 1958, now abandoned.

What is claimed is:

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1. In a jet device for directing a fluid flow toward a molten bath comprising, an inner tube defining a central coolant conduit, a second tube outwardly spaced therefrom to define an annular fluid passage therebetween, a third tube outwardly spaced from the second tube to define a second outer annular coolant passage, means secured to the upper ends of said tubes for supplying said passages with flows of said fluid and a coolant, a nozzle associated with the forward end of said tubes for directing flows of fluid toward the bath and having passages for circulating said coolant, the improvement therewith which comprises the combination of a highly conductive nozzle having a forward face exposed to the bath, said nozzle sealably engaging the forward end of each of said tubes for receiving oxygen therefrom, and for circulating said coolant fluid, downwardly directed oxygen orifices communicating the first of said annular passages with said forward face, said orifices adjacently disposed to provide lateral spacing therebetween, a central chamber in said nozzle, the forward wall of said chamber constituting the rear surface of the nozzle face, said chamber having an inlet engaging the inner tube to receive a flow of coolant therefrom, uniformly cross-sectional bores outwardly radiating from said chamber each of said bores having an outlet port opening into said second annular coolant passage thereby permitting coolant from said chamber to be outwardly directed into said coolant passages in smooth, high-velocity streams and to enter the lower end of said passage, said radial bores being positioned substantially parallel to the nozzle face and disposed such that at least one of said bores lies intermediate each adjacent pair of downwardly extending orifices, said second annular passage terminating at an annular wall forwardly adjacent said outlet ports, said wall being provided with rearwardly extending integral projections positioned such that at least one of said projections completely occupies the peripheral interval separating each adjacent pair of outlet ports thereby defining a plurality of rearwardly extending channels, the lower end of said channel adapted to receive coolant streams from said outlet ports, and the channel upper end being outwardly divergent to combine the respective coolant streams into an annular flow.

2. In a jet having a nozzle substantially as described in claim 1 wherein the rearwardly extending projections constituting the forward wall of the outer annular passage comprises a plurality of peripherally disposed substantially triangular sections each adjacent pair of said triangular sections defining a rearwardly extending channel adapted to receive a stream of coolant in a constricted portion thereof and to direct said respective streams rearwardly along outwardly divergent channel walls, and thereby combine the streams into a single annular flow substantially free of turbulence.

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