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NOZZLE

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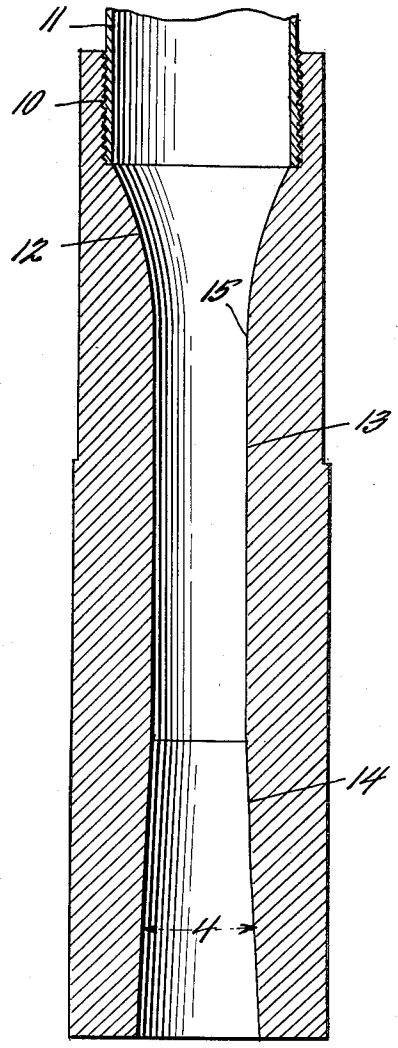

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NOZZLE

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The present invention relates to a nozzle for the injection into a metal bath of powdered or granular materials suspended in a gas or gaseous mixture.

In usual practice an injection nozzle of the general type here involved is mounted and supported on one end of a delivery conduit and the gas-solid mixture is transported under pressure in said conduit to the injection nozzle at its discharge end. The latter is generally provided at its end with a converging-diverging passage the purpose of which is to permit the mixture to expand upon emerging from the nozzle in the form of a uniform jet having a very high velocity.

The well known converging-diverging passage generally used for this purpose has a converging section which communicates directly with the orifice of the nozzle on its intake side, and on its discharge side communicates with a diverging passage section. The orifice is preferably of reduced section, the diameter of which is determined by the thermodynamic properties of the fluid injected and by the value of the flow to be obtained at the outlet of the nozzle.

In conventional nozzles the constricted orifice has an axial length less than its diameter. The lengths should be as short as possible to maintain frictional resistance at a minimum, since friction is proportional to length. In the case of the injection of a gaseous fluid not mixed with solids, this form of orifice makes it possible readily to obtain a uniform jet.

In all such known nozzles, however, the length of the converging intake sections is in all cases independent of the length of the constricted orifice.

When a gaseous fluid which does not contain solids in suspension is injected, the above characteristics of the converging-diverging device are sufficient to obtain a uniform jet at the outlet of the injection nozzle.

On the other hand, in case of the injection of gaseous fluid containing powdered or granular solids in suspension, it is found that the known types of nozzles such as described above are incapable of obtaining a uniform jet. Furthermore, in the methods for injection into a metal bath of finely divided solids suspended in a gas, it is of utmost interest to obtain a jet of a very small cone angle capable of penetrating deeply into the bath and the known injection nozzles do not make it possible to satisfy this important condition. If there is employed a nozzle which merely complies with the general characteristics of the prior art, as indicated above, it is found that despite the selection of a small cone angle of the diverging discharge section of the nozzle passage, the fluid jet emerging from such section has a tendency to spread out, which may constitute a substantial drawback.

The object of the present invention is to provide a nozzle for ejection of suspension of finely divided solids in gases wherein the ejected suspension assumes the form of a high velocity jet flow of powdered or granular products suspended in a gas stream of generally uniform small diameter capable of penetrating deeply into the bath, because of its small cross-section and its velocity.

The nozzle which is the subject matter of the invention is characterized essentially by the fact that the diameter D of its converging inlet passage section, the length L of the said section, the diameter d of the orifice section and the length C of the orifice section are related to each other by the formula

$$\frac{D}{d}=1+K\frac{L}{C}$$

in which K is greater than 2.

Advantageous results have been obtained with a nozzle, the dimensions of which satisfy the said formula in which K is between 2.5 and 3.

Generally, the various sections of the nozzle passage have circular interior cross-sections. This is why in the definition of the invention given above it has been indicated that the characteristic of the sections to be used in the formula is their diameter. It is, however, clear that it does not go beyond the scope of the present invention to produce a nozzle of non-circular section, for instance elliptical section. In this case, the characteristic of the sections of the nozzle passage to be used is their largest dimension, for instance, the major axis of the ellipse if the section is elliptical.

It has furthermore been found that advantageous results are obtained when using a nozzle in accordance with the invention in which the axial length of the orifice section is greater than twice its internal diameter and preferably between 3 and 5 times its said internal diameter.

It has also been found, in accordance with the invention, that the jet issuing from the nozzle comprises a more uniform suspension of generally uniform cross-sectional area throughout its length than is obtained at the outlet of the nozzle if the nozzle as described above has at the same time a diverging discharge passage section, the total cone angle of which, formed by two diametrically opposite generatrices, is less than or equal to 6 degrees, contrary to the known currently employed devices in which this angle is generally greater than 6 degrees.

The nozzle of the invention can be employed whatever the shape of the converging inlet passage section, and the generatrix of the cone frustum can be straight or curved.

Thus, it has been found advantageous in accordance with the invention, in order to obtain a more uniform jet of smaller cone angle to furthermore impart to its converging intake section an outwardly concave profile formed by the revolution around the axis of the device of a curve which is concave towards the outside and which is connected on the one hand to the inner conduit of the nozzle and tangent on the other hand to the orifice of the nozzle. This special form of converging intake passage section facilitates the flow of the jet of gas-solid mixture and has been found to minimize its spreading out upon emerging in the form of a jet from the nozzle.

In the accompanying drawing there is shown an axial section through a nozzle embodying the invention, and a portion of the delivery conduit on which it is mounted.

The nozzle is preferably of integral metal construction having an axial or longitudinal passage extending rectilinearly therethrough from its intake end through its discharge end. At its intake end the passage is enlarged and internally threaded for coupling to a supply conduit 11 on which it is supported and through which a suspension of finely divided solids in gases is delivered to the nozzle.

The nozzle passage includes an intake section 12 converging from its juncture with conduit 11 in the discharge direction toward the orifice section 13. A further passage section 14 communicating with the discharge end

of the orifice section **13**, diverges therefrom conically to the discharge end of the nozzle.

In the illustrated embodiment the length of the orifice **13** is equal to 4.1 times the inside diameter of the said orifice. The angle **4** of the diverging passage section **14** is equal to 4 degrees 40 minutes. The converging passage section **12** has an outwardly concave profile and is tangent at **15** to the orifice **13**. Furthermore, the dimensions of the converging passage **12** and of the orifice **13** are related to each other by the formula

$$\frac{D}{d}=1+K\frac{L}{C}$$

in which K equals 2.2.

If a water-cooled conduit **11** is employed, the converging-diverging device in accordance with the invention can be introduced and fastened in suitable manner to the inside of the cooled end of the conduit. There can also be produced a conduit the cooled end of which includes the nozzle as an integral portion.

As has been stated above, the essential advantage of the device which is the subject matter of the present invention is that it assuredly makes it possible to obtain a fine, compact, uniform jet which penetrates deep into the bath. Another advantage of the device which is the subject matter of the invention is that it makes it possible to obtain instantaneously and with full assurance a jet which is spread out more and penetrates less deeply into the bath when desired, for instance, in order to cause or favor the foaming of the slag during a refining operation. For this purpose, it is sufficient to increase the pressure of the gas upstream of the nozzle to above the pressure at which it normally operates when giving a fine jet. Thus, by increasing the pressure of the gas upstream of the nozzle by 1 kilogram per square centimeter, the cross-section of the jet can be increased by 2 to 10% depending on the value of the normal pressure and the flow of the fluid. By way of illustration, and not of limitation, a nozzle in accordance with the invention giving a fine jet at a normal pressure of 5 kilograms per square centimeter gave a jet of a cross-section 18 to 25% larger when the inlet pressure of the gas was increased to 8 kilograms per square centimeter.

Having thus described our invention, we claim:

1. An injection nozzle for injecting a gaseous suspension of finely divided solids in the form of a fine jet of generally uniform cross-section into molten metal from above the surface of said metal, said nozzle being formed with a continuous passage therethrough, including an orifice of uniform diameter located medially of the length of said passage, a conical intake passage section on the intake side of said orifice converging toward said orifice, and a conical discharge passage section of uniformly increasing diameter throughout its length in a discharge direction extending from said orifice to the discharge end of the nozzle, the maximum diameter D and length L of the intake passage section, and the diameter d and length C of the orifice being related to each other by the formula

$$\frac{D}{d}=1+K\frac{L}{C}$$

in which K is a constant value greater than 2.

2. A nozzle as defined in claim 1, in which K equals a value between 2.5 and 3.

3. A nozzle according to claim 1 in which the ratio C/d of the length of the orifice to its diameter is greater than 2.

4. A nozzle according to claim 1 in which the ratio C/d of the length of the orifice to its diameter is between 3 and 5.

5. A nozzle according to claim 1 in which the conical intake passage section is defined by a surface generated by the revolution around the axis of said passage section of a generatrix curved in the plane of said axis with its convex side presented away from said axis and which is tangent to the said orifice of the converging-diverging device.

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