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APPARATUS FOR THE OXIDATION OF METAL POWDERS

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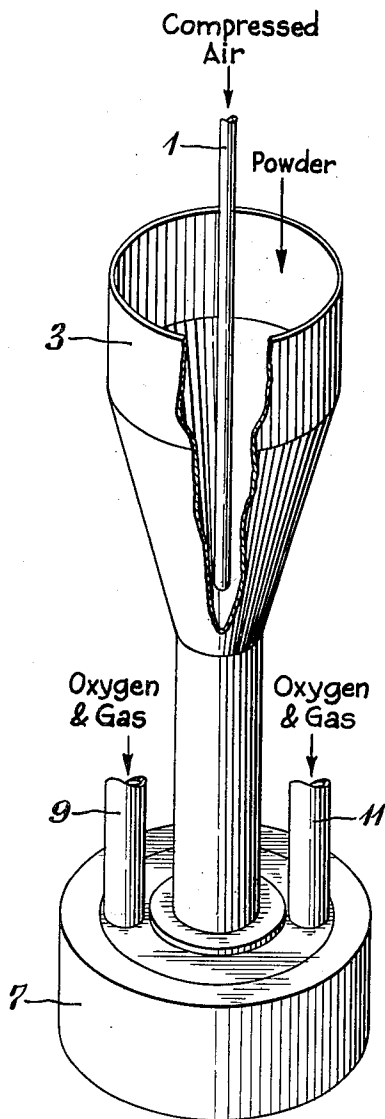


Fig. 1.

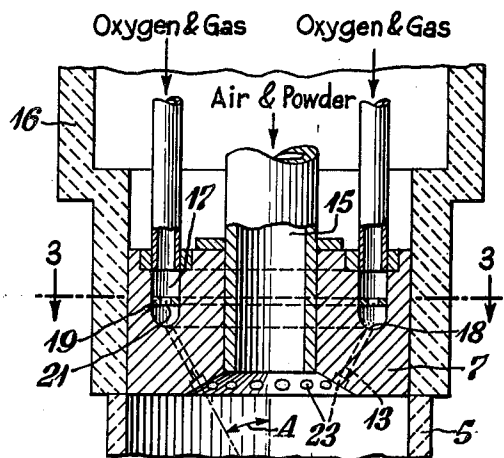


Fig. 2.

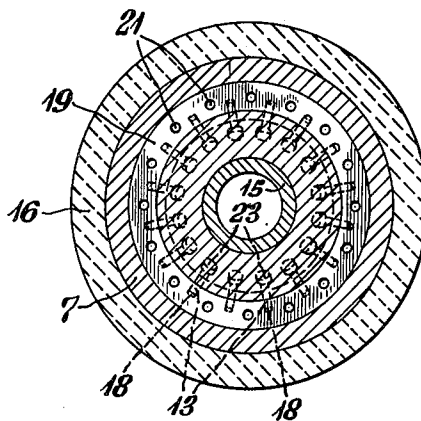


Fig. 3.

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APPARATUS FOR THE OXIDATION OF
METAL POWDERS

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13 Claims. (Cl. 23—277)

The present invention relates to the oxidation of metal powders and more particularly to a burner for the oxidation of metal powders.

In the processes of the metallurgical and related arts, oxidized metallic material in the form of powder, is often required, or highly desirable, as an alloy addition agent or for other purposes.

However, in order to be of practical utility, the oxidized metal powder must contain a high proportion of combined oxygen and be of substantially uniform oxygen content.

Additionally, from an economic and industrial point of view, it is important that the apparatus by which the oxidized metal powder is produced, be capable of continuous, high capacity operation while also permitting prompt shut-down and subsequent start-up whenever intermittent operation is dictated. It is further desirable, for maintenance purposes and for other obvious reasons that the apparatus for producing the oxidized metal product be of uncomplicated and inexpensive design.

A review of the published art and an investigation of commercially available burners have not uncovered any apparatus suitable for the purposes described above.

Accordingly it is an object of the present invention to provide an apparatus for the continuous production of uniformly oxidized metal powder having high combined oxygen content.

It is another object to provide an apparatus for the oxidation of metal powders which is capable of continuous operation and which also permits intermittent operation without requiring maintenance or cleaning between periods of use.

It is a further object of the present invention to provide a burner for the oxidation of metal powders in which the occurrence of flame-out or flash-back is practically eliminated.

These and other objects will be apparent from the following description and claims, taken in conjunction with the drawings, in which:

FIGURE 1 shows, somewhat schematically, the general arrangement of the apparatus of the present invention adapted for use with a furnace.

FIGURE 2 is a sectional elevational view of the burner assembly of FIGURE 1 in combination with a furnace, and

FIGURE 3 is a plan view taken along 3—3 of FIGURE 2.

An apparatus which satisfies the objects of the present invention comprises, in combination, a furnace; means for producing a stream of metal powder; a body member having a bore of substantially circular cross-section communicating between the powder-stream producing means and the furnace; a plurality of substantially identical conduits arranged symmetrically around the bore, converging toward a point within the furnace on the

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longitudinal axis of the bore and communicating with the bore interior the furnace; and fuel gas and oxygen supply means communicating with the conduits at the inlets thereof for providing a flow of fuel gas and oxygen mixture through the respective conduits into the furnace at a common velocity sufficient to establish, upon ignition of the mixture, a flame at the intersection of the longitudinal axis of the bore with the longitudinal axes of the conduits. The flame which is thus produced is a substantially continuous conic shaped oxidizing flame which extends from immediately adjacent the outlets of the conduits, in the direction of powder flow, and converges at the longitudinal axis of the bore.

The above-described apparatus, together with other embodiments of the present invention, will be more readily understood by referring to the drawing.

In the drawing, FIGURE 1 illustrates a somewhat schematic representation of the apparatus of the present invention adapted for use with a furnace and shows a pipe 1 through which a pressurized carrier gas is fed to fluidize or entrain a metal powder which is introduced into hopper 3. The carrier gas, which can be oxygen, air or other similarly suitable gas, is regulated by known techniques so that the particles of metal introduced into hopper 3 are maintained isolated from each other in a stream, and eventually pass into the furnace which is indicated as 5 in FIGURE 2. The stream of metal powder thus provided passes through a burner assembly, enclosed in body member 7, and a mixture of fuel gas and oxygen or air is also introduced into the burner assembly through tubes 9 and 11.

The details of the novel burner of the present invention are illustrated in FIGURES 2 and 3 which show a plurality of substantially identical conduits 13, symmetrically arranged around a bore 15 having a circular cross-section and through which the metal powder stream produced in hopper 3 passes into the furnace 5. Body member 7, in which conduits 13 are located, is held in position by means of holder 16. The furnace 5 is of conventional design and comprises a vessel or structure suitable for containing a metal powder oxidation reaction. The mixture of fuel gas and oxygen, introduced through tubes 9 and 11, passes through manifold 17, containing baffle 19, and exits through tubular conduits 13 into the furnace 5. An oxidizing flame is provided in the furnace upon ignition of the gas mixture by a suitable ignition means (not shown). It has been discovered that by arranging conduits 13 in a particular configuration, the metal powder which passes into the furnace through bore 15 is uniformly oxidized and contains an unexpectedly high proportion of combined oxygen, further, an unusually high and constant rate of oxidized powder production is additionally achieved. The abovementioned benefits are provided by arranging conduits 13 whereby the longitudinal axes thereof intersect the longitudinal axis of bore 15 at a common angle of between about 15 degrees and about 40 degrees; this angle is indicated as A in FIGURE 2. With conduits 13 thus disposed a conic shaped flame can be readily provided, having its apex on axis of bore 15 at the point of intersection with the longitudinal axes of conduits 13. The conic shaped flame which is produced possesses a high degree of turbulence, in addition to being continuous, and extends from immediately adjacent the out-

let of the conduits substantially in alignment with the longitudinal axis of bore 15. It has been observed that while uniform, high quality oxidation of metal powders, and high rates of production are obtained with the conduits 13 arranged in the angular range of 15 to 40 degrees, when angles outside of this range are employed, various types of defective operation result. For example, either the bore tends to become clogged, or the oxidizing flame tends to become less turbulent, discontinuous, and prone to instability and flashback. These undesirable phenomena are accompanied by substantially decreased and non-uniform oxidation, and substantially lower and non-uniform rates of production. For overall optimum results, it has been found that angular range of 25 to 30 degrees is preferred.

In addition to arranging the conduits as described above, it is necessary to provide in the present invention a means whereby the velocity of the fuel gas-oxygen mixture through the respective conduits is substantially the same in order to thereby ensure a continuous symmetrical oxidizing flame. Such a means is illustrated in FIGURE 2 where an annular manifold chamber 17 is shown connected directly on one side to tubes 9 and 11 and on the opposite side to inlets 18 of conduits 13, with a baffle 19 disposed approximately midway between the tubes and the conduit inlets. The baffle 19 is arranged transverse to the axis of bore 15 and contains a plurality of substantially identical circular openings, equal in number to the conduit inlets. The baffle 19 is positioned, as shown in the drawing, so that the baffle openings 21 are staggered with respect to the conduit inlets whereby the pressure of the incoming fuel-oxygen mixture, at the conduit inlets, is substantially equalized, thus providing the same velocity at the outlets of each of the conduits. It has been found that best results are obtained in this respect when the cross-sectional area of the openings of the baffle are about 1.7 to 2.4 the cross sectional area of the conduits. It is also preferred, to ensure a common and relatively constant gas velocity in the conduits, that the conduit inlets connect with the manifold at an angle normal to the manifold chamber and at a position remote from the manifold chamber side wall.

In a further embodiment of the present invention the conduits 13 are designed to have a length to diameter ratio of between about 9 and about 12. It has been found that conduits which are so dimensioned provide a burner which is practically free from any tendency towards flame discontinuity.

In a still further embodiment of the present invention, the bore 15 is flared in the portion adjacent the outlets 23 of conduits 13, as shown in FIGURE 2, and the flared portion of the bore is arranged to be perpendicular to the longitudinal axes of the conduits. In this embodiment, substantially increased turbulence is provided in the flame zone which ensures a high degree of uniform oxidation of the metal powder. In addition, to further improve the flash-back resistant properties of the burner of the present invention, the outlets of conduits 13 are counter-bored. The diameter of the counter-bore is preferably about twice the diameter of the conduit, and the depth of the counter-bore is preferably between one and two times the diameter of the conduit. The counter-bore feature is shown in the drawing.

In the apparatus of the present invention, the specific number and specific cross-sectional area of the conduits is not critical. It is essential however, that the conduits 13 be equally spaced about the longitudinal axis of bore 15. It is also necessary that the number and size of the conduits be sufficient to permit the development of a continuous flame immediately adjacent the conduit outlets extending to the intersection of the conduit axes with the axis of the bore. An example of a burner in accordance with the present invention is illustrated in FIGURES 2 and 3 and described as follows:

Example I

Number of conduits-----	16 conduits, arranged with outlets in a 2 inch diameter circle.
5 Diameter of each conduit----	0.089 inch.
Length of each conduit----	1 inch.
Diameter of counter-bore----	0.136 inch.
Depth of counter-bore-----	$\frac{3}{32}$ inch.
Angle of intersection of conduit axes with bore axes--	30 degrees.
10 Mean diameter of manifold chamber-----	2½ inches.
Cross-section of manifold chamber-----	$\frac{3}{4}$ inch x $\frac{3}{8}$ inch.
15 Number of baffle openings--	16.
Diameter of baffle openings-----	$\frac{1}{8}$ inch.
Number of fuel gas and oxygen inlets-----	2, located diametrically opposed above manifold chamber opposite conduit inlets.
20 Bore -----	$\frac{3}{4}$ inch diameter flared adjacent conduit outlets and normal to axes of conduits.
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Comparative results illustrating the benefits of the present invention are set forth in the following examples:

Example II

A stream of finely divided high-carbon ferrochrome (approximately 90 percent passing through a screen of 325 Tyler mesh) having an average composition of about 67 percent chromium, about 23 percent iron, about 5 percent carbon, less than 2 percent silicon, and between about 0.2 and 0.8 percent oxygen, the remainder being minor elements and incidental impurities, was reacted in a vertical furnace at oxidizing temperature with oxygen in a mixture with gaseous hydrocarbons. The furnace was provided with a commercially available conventional burner having conduits arranged surrounding and substantially parallel to the stream of metal powder. An average production rate of 18.49 pounds per minute was obtained. The final product averaged an oxygen content (as combined oxides) of 22.42 percent. The above actual production figures are for a period of seven consecutive days.

All attempts to increase the continuous throughput and the oxygen content of the product were ineffective.

Example III

After having replaced the conventional burner with one similar to that shown in the drawing, and described in Example I, the furnace of Example II was operated under substantially similar conditions. A throughput averaging 22.45 pounds per minute was achieved without difficulty and the final product contained an average of 26.38 percent oxygen. The above figures are for a period of seven consecutive days and represent an improvement of more than 24 percent in capacity and about 17.7 percent in quality (oxygen content).

Feed rates as high as 30 pounds per minute have been easily achieved with the burner of the present invention.

From the above discussion it can be seen that a novel and beneficial apparatus is provided for the oxidation of metal powders. In the practice of the present invention, the stream of metal powder introduced into the furnace is completely penetrated by a continuous and turbulent oxidizing flame with a resultant uniform oxidation of the powder. In addition, the oxidized powder which is produced possesses a substantially increased proportion of combined oxygen. Moreover, the burner assembly of the present invention is easily constructed, and free from flash-back, flame-out and clogging.

The apparatus of the present invention is advanta-

geously practiced in the process disclosed in co-pending U.S. application 6,740.

What is claimed is:

1. An apparatus for oxidizing metal powder which comprises, in combination, a furnace; means for producing a stream of metal powder; a body member having a bore of substantially circular cross-section, said bore communicating with said furnace and said powder stream-producing means for the passage of a stream of metal powder through said bore into said furnace; a plurality of substantially identical tubular conduits symmetrically arranged around the longitudinal axis of said bore and communicating with said bore, at the bounding surface thereof within said furnace, at respective outlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore; said conduits being arranged having their respective longitudinal axes intersecting the longitudinal axis of said bore at a common angle of between about 15° and 40° and having their inlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore; and fuel gas and oxygen supply means communicating with said conduits at the inlets thereof for providing a flow of fuel gas and oxygen mixture through said conduits into said furnace at a common velocity sufficient to establish when said mixture is ignited, a flame at the intersection of the longitudinal axis of said bore with the longitudinal axes of said conduits, whereby a substantially continuous conic shaped oxidizing flame reaction zone is produced in said furnace extending from immediately adjacent the outlets of said conduits and substantially in alignment with the longitudinal axis of said bore.

2. An apparatus in accordance with claim 1 wherein the longitudinal axes of said conduits intersect the longitudinal axis of said bore at an angle of between about 25° and 30°.

3. An apparatus in accordance with claim 1 wherein said bore is flared in the portion thereof adjacent said conduit outlets, the flared portion of said bore being substantially perpendicular to the longitudinal axes of said conduits.

4. An apparatus in accordance with claim 1 wherein said conduits are counter-bored at the outlets thereof, the counter-bore having a diameter about twice the diameter of a conduit and having a depth between about one and two times the diameter of a conduit.

5. An apparatus in accordance with claim 1 wherein said conduits have a length to diameter ratio of from about 7 to about 12.

6. An apparatus for oxidizing metal powder which comprises, in combination, a furnace; means for producing a stream of metal powder; a body member having a bore of substantially circular cross-section, said bore communicating with said furnace and said powder stream-producing means for the passage of a stream of metal powder through said bore into said furnace; a plurality of substantially identical tubular conduits symmetrically arranged around the longitudinal axis of said bore and communicating with said bore at the bounding surface thereof within said furnace at respective outlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore; said conduits being arranged having their respective longitudinal axes intersecting the longitudinal axis of said bore at a common angle of between about 15° and 40°; an annular chamber within said body member concentric with and extending along said bore away from said conduit inlets and communicating directly therewith; at least one gas inlet means located opposite said conduit inlets communicating with said chamber for the introduction of fuel gas and oxygen thereto; and baffle means in said chamber disposed transverse to the longitudinal axis of said bore between said gas inlet means and said conduit inlets, said baffle means having a plurality of openings therein, equal in number to said conduit inlets, and staggered with respect thereto.

7. An apparatus in accordance with claim 6 wherein the cross-sectional area of each baffle opening is between 1.7 and 2.4 times the cross-sectional area of said conduit inlet.

8. An apparatus in accordance with claim 6 wherein the longitudinal axes of said conduits intersect the longitudinal axis of said bore at an angle of between about 25° and 30°.

9. An apparatus in accordance with claim 6 wherein said bore is flared in the portion thereof adjacent said conduit outlets, the flared portion of said bore being substantially perpendicular to the longitudinal axes of said conduits.

10. An apparatus in accordance with claim 6 wherein said conduits are counter-bored at the outlets thereof, the counter-bore having a diameter about twice the diameter of a conduit and having a depth between about one and two times the diameter of a conduit.

11. An apparatus in accordance with claim 6 wherein said conduits have a length to diameter ratio of from about 7 to about 12.

12. An apparatus for oxidizing metal powder which comprises, in combination, a furnace; means for producing a stream of metal powder; a body member having a bore of substantially circular cross-section, said bore communicating with said furnace and said powder stream-producing means for the passage of a stream of metal powder through said bore into said furnace; a plurality of substantially identical tubular conduits having a length to diameter ratio of between about 7 and 12 being symmetrically arranged around the longitudinal axis of said bore and communicating with said bore, at the bounding surface thereof within said furnace, at respective outlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore, said bore being flared in the portion adjacent said conduit outlets with said flared portion being perpendicular to the longitudinal axes of said conduits; said conduits having their inlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore and having their respective outlets counter-bored, the diameter of said counter-bore being twice the diameter of a said conduit and the depth of said counter-bore being between one and two times the diameter of a said conduit and each said conduit being arranged having its longitudinal axis intersecting the longitudinal axis of said bore at an angle of between about 15° and 40°; an annular chamber disposed within said body member concentric with and extending along said bore away from said conduit inlets and communicating directly therewith; at least one gas inlet means located opposite said conduit inlets communicating with said annular chamber for the introduction of fuel gas and oxygen thereto; and baffle means in said chamber disposed transverse to the longitudinal axis of said bore between said gas inlet means and said conduit inlets, said baffle means having a plurality of openings, equal in number to said conduit inlets, and staggered with respect thereto, the cross-sectional area of each said baffle opening being between about 1.7 and 2.4 times the cross-sectional area of a said conduit.

13. A burner for oxidizing metal powders which comprises a body member having a bore of substantially circular cross-section, said bore adapted to communicate between a furnace and a powder stream-producing means for the passage of a stream of metal powder through said bore into said furnace; a plurality of substantially identical tubular conduits symmetrically arranged around the longitudinal axis of said bore and communicating with said bore, at the bounding surface thereof within said furnace, at respective outlets disposed in a circular configuration perpendicular to the longitudinal axis of said bore; said conduits being arranged having their respective longitudinal axes intersecting the longitudinal axis of said bore at a common angle of between about 15° and 40° and having their inlets disposed in a circular configura-

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tion perpendicular to the longitudinal axis of said bore; and fuel gas and oxygen supply means communicating with said conduits at the inlets thereof for providing a flow of fuel gas and oxygen mixture through said conduits into said furnace at a common velocity sufficient to establish when said mixture is ignited, a flame at the intersection of the longitudinal axis of said bore with the longitudinal axes of said conduits, whereby a substantially continuous conic shaped oxidizing flame reaction zone is produced in said furnace extending from immediately adjacent the

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outlets of said conduits and substantially in alignment with the longitudinal axis of said bore.

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