

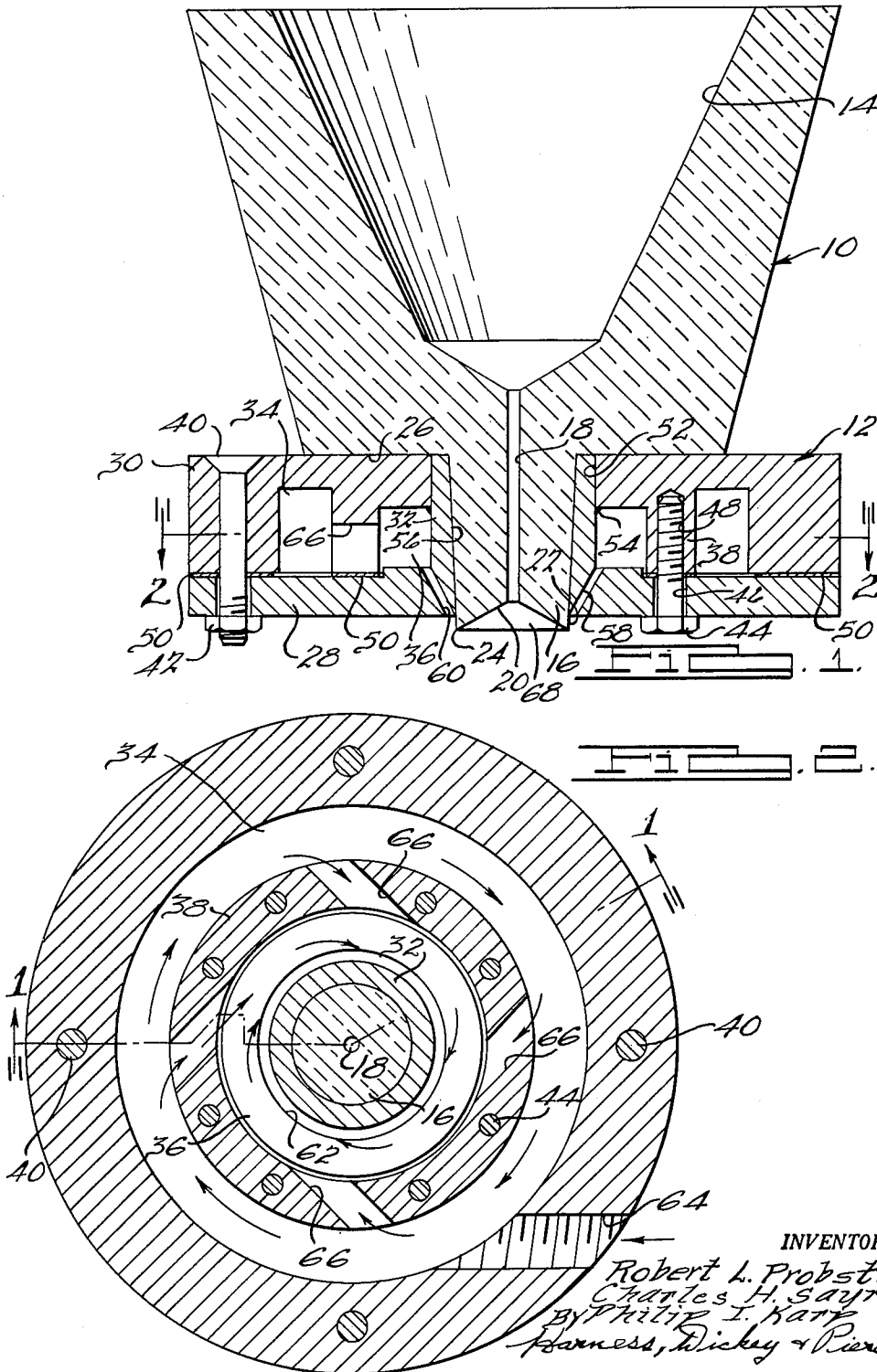
May 31, 1966

R. L. PROBST ET AL

3,253,783

ATOMIZING NOZZLE

Filed March 2, 1964



INVENTORS.

Robert L. Probst.

Charles H. Sayre.

By Philip I. Karp

Harness, Wicks & Pierce

ATTORNEYS.

1

2

3,253,783

ATOMIZING NOZZLE

Robert L. Probst, Ann Arbor, Charles H. Sayre, Ypsilanti, and Philip I. Karp, Ann Arbor, Mich., assignors to Federal-Mogul-Bower Bearings, Inc., Detroit, Mich., a corporation of Michigan

Filed Mar. 2, 1964, Ser. No. 348,673

2 Claims. (Cl. 239—82)

The present invention broadly relates to an apparatus for making finely particulated metallic powders, and more particularly to an improved pouring cup and nozzle assembly which is capable of atomizing molten metal or metal alloys for producing metallic powders of controlled particle size. More specifically, the present invention is directed to an improved pouring cup and nozzle assembly over that disclosed in prior United States Patent No. 2,968,062 granted January 17, 1961, and assigned to the same assignee as the present invention whereupon improvements are achieved in the shape and in the uniformity of the size of the metallic powders produced.

Various metals and metal alloys in a finely divided state are in widespread commercial use for forming a variety of metallic and composite particles employing powder metallurgical techniques. The metal and metal alloy powders used are of a controlled particle size depending upon the intended end use and are dense and of low oxide content. Various techniques have heretofore been used or proposed for use for forming such metallic powders which have been found deficient for one or more reasons including the relatively low yields obtained, the irregularity in the shapes of the metallic powder particles obtained, and the large variations in size of the powder particles produced.

It is accordingly a principal object of the present invention to provide an improved pouring cup and atomizing nozzle assembly which provides for substantial improvements in atomizing molten metals and molten metal alloys and attaining substantially high yields of metallic particles which are of more uniform size and shape than have been possible with the techniques heretofore known to the art.

Another object of the present invention is to provide an improved atomizing nozzle and pouring cup assembly which is operative to effect the formation of dense metallic particles of a controlled size containing low oxide contents and which is of simple construction, of economical manufacture and of versatile and efficient operation.

The foregoing and other objects and advantages of the present invention are achieved by providing means forming a downwardly extending discharge passage for molten metal including an end portion having an outer surface and an annular downwardly and outwardly inclined lower end surface communicating at substantially the center of the upper end thereof with a discharge end of the passage and intersecting the outer surface at the lower end thereof forming on outer edge. An annular nozzle is arranged in substantially concentric relationship with the annular surface and is inclined downwardly toward the outer edge. Means are provided including a body for supplying a stream of gas for discharge through the nozzle in the form of a converging vortex directed across the outer edge effecting the drawing of molten metal out of the lower end of the discharge passage and downwardly along the inclined surface whereupon the molten metal is fragmentized or atomized as it flows off the outer edge forming dense metal particles of the desired size and configuration.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a transverse vertical sectional view of the pouring cup and nozzle assembly constructed in accordance with the preferred embodiments of the present invention and wherein the section of the nozzle assembly is taken along the line 1—1 of FIGURE 2, and

FIGURE 2 is a horizontal sectional view through the nozzle assembly shown in FIGURE 1 and taken along the line 2—2 thereof.

Referring now in detail to the drawing, the pouring cup and nozzle assembly comprising the present invention consists of a receptacle or cup indicated at 10 which is removably seated on the upper surface of a nozzle unit indicated at 12. The cup 10 is formed of a suitable ceramic or other refractory material which is heat resistant and is capable of being heated to a temperature corresponding substantially to the temperature of the molten metal or metal alloy to be atomized. The cup 10 comprises a body formed with an upwardly directed cavity 14 into which the molten metal is poured and a downwardly extending stem portion 16 formed with an axially extending passageway 18 disposed in communication at its upper end with the cavity 14 and at its lower end with an annular downwardly and outwardly inclined conical surface 20. The opening of the lower end of the passageway 18 is located at substantially the center of the conical surface 20 and the lower edges of the conical surface intersect the outer surface 22 of the stem portion 16 forming a relatively sharp edge indicated at 24 of an annular configuration.

The cup 10 is formed with an annular flat base 26 which is adapted to be seated against the upper surface of the nozzle unit 12 when in the assembled condition. The nozzle unit 12 comprises a base plate 28, an upper plate 30 and a nozzle insert 32. The upper plate 30 is formed with a first annular cavity 34 and a second annular cavity 36 which are separated from each other by an annular wall 38. The annular cavity 34 serves as an inlet manifold and the annular cavity 36 serves as a discharge manifold for a pressurized gas for the purposes subsequently to be described.

The base plate 28 and the upper plate 30 are securely fastened to each other as exemplarily shown in the drawings by means of four countersunk screws 40 and nuts 42 extending in circumferentially spaced relationship around the outer edge of the nozzle unit and a series of machine screws 44 which extend upwardly through bores 46 in the base plate 28 and are disposed with the threaded shank portions thereof in threaded engagement in threaded bores 48 in the annular wall 38. The parting edges between the base plate 28 and upper plate 30 at their points of contact are separated by suitable heat-resistant gaskets 50 preventing leakage of the gas therebetween.

A central bore 52 is formed in the center of the upper plate 30 in which the nozzle insert 32 is press fit and may be welded as at 54 forming a gas-tight unitary joint. The nozzle insert 32 is formed with an internal tapered bore 56 for removably receiving and centrally positioning the stem portions 16 of the cup 10. The lower end portion of the nozzle insert 32 is formed with a downwardly and inwardly directed conical surface 58 which at its lowermost point terminates at a point spaced above the annular edge 24 at the lower end of the stem portion 16.

The base plate 28 is formed at its center with a conical downwardly and inwardly directed surface 60 which is disposed concentric to and in uniformly spaced relationship relative to the conical surface 58 on the nozzle insert 32. The relative dispositions of the conical surfaces 58, 60 form an annular nozzle opening 62 which is disposed at its upper end in communication with the annular cavity 36 and at its lower end is positioned in

concentric relationship relative to the annular edge 24 at the bottom of the stem portion 16. In the exemplary arrangement illustrated in the drawing, the annular nozzle opening is inclined at an angle of about 45° from the vertical and the width of the opening may conventionally range from about 0.010 to about 0.040 inch, depending on such factors as the type of gas employed, the pressure and/or flow rate of the gas discharged from the annular nozzle opening, the specific metal being atomized, and the particle size of the resultant metallic powder desired. The stem portion 16 of the cup 10 is conventionally sized so that the annular edge 24 at the bottom thereof is spaced at least $\frac{1}{16}$ inch below the outlet of the annular nozzle opening 62 whereby at least a portion of the gas stream discharged from the nozzle opening impinges directly against the annular edge.

The pressurized gas for discharge through the annular nozzle opening 62 is admitted into the nozzle unit 12 through a threaded bore 64 as shown in FIGURE 2, which is adapted to receive a suitable threaded coupling on the end of a supply pipe. The threaded bore 64 is oriented in a direction substantially tangential relative to the annular cavity 34 so as to impart high speed rotation of the gas in a clockwise direction as viewed in FIGURE 2 in the annular cavity. The flow of rapidly circulating gas from the outer annular cavity 34 to the inner annular cavity 36 is achieved through a plurality of bores or ports 66 extending through the annular wall 38 in a direction substantially tangential relative to the annular wall as shown in FIGURE 2. In the exemplary embodiment shown, four such ports 66 are provided which are disposed at equal circumferentially spaced intervals providing for a substantially uniform flow of gas from the outer annular cavity 34 to the inner annular cavity 36 along the entire circumference thereof. The tangential ports 66 are oriented in the same direction as the direction of circulation of the gas around the outer annular cavity 34 whereupon the gas entering the inner annular cavity 36 is also possessed of a high circular velocity in a clockwise direction as viewed in FIGURE 2. The circulating gas in the inner annular cavity 36 moves inwardly toward and is finally discharged from the annular nozzle opening 62 in the base thereof in the form of a downwardly extending converging high speed vortex against the lower end edge of the stem portion 16 effecting fragmentation of the molten metal flowing off the annular edge 24 thereof.

It will be apparent from the construction of the nozzle unit 12 that the injection of the pressurized gas tangentially imparting a high velocity rotation thereof and a further provision of the annular wall having the tangential ports 66 therein effects substantially uniform distribution of the gas resulting in a substantially uniform discharge of the gas along the entire circumferential length of the annular nozzle opening 62. The uniformity in the discharge of the gas from the annular nozzle opening 62 assures increased uniformity in the flow of molten metal off the annular edge 24 and a more uniform fragmentation or atomization thereof resulting in powdered metal products of increased uniformity and size and of improved spherical configuration. In accordance with the practice of the present invention any one of a variety of gases which are substantially inert so as to minimize oxidation of the molten metal during atomization can be satisfactorily employed of which nitrogen is typical and constitutes a preferred gas propellant. The gas can be introduced into the nozzle unit 12 at pressures ranging from about 70 p.s.i. up to about 1,000 p.s.i. The specific pressure employed within the aforementioned range will vary depending on the particular molten metal being atomized and the particle size of the resultant metallic powder desired.

In operation, a pressurized gas is introduced into the nozzle unit through the threaded bore 64 and is discharged in the form of a high speed converging vortex against the

annular edge 24 of the stem portion of the cup 10. The molten metal which is contained within the cavity 14 of the cup 10 is drawn downwardly through the passageway 18 which may conventionally range from about $\frac{1}{16}$ to about $\frac{3}{8}$ inch in diameter and flows outwardly along the inclined conical surface 20 toward the annular edge 24. The flow of the molten metal is achieved by means of the vacuum created within a frusto-conical space 68 defined by the conical surface 20 at the end of the stem portion 16 as a result of the high velocity flow of gas inwardly across the annular edge 24 at the base of the stem. The vacuum thus created also serves to tightly seat the tapered stem portion 16 within the tapered bore 56 of the nozzle insert. As the result of the improved uniformity of the gas stream passing the annular edge 24, a substantially uniform film of molten metal flows downwardly and outwardly across the conical surface 20 toward the annular edge 24 at which point it is fragmented or atomized into fine sized globules by the impinging stream of gas which is traveling in a direction at substantially right angles to the direction of flow of the metal outwardly along the conical surface 20. The rotative as well as the downward component of movement of the stream of air discharged from the annular nozzle opening effects atomization of the molten metal assuring the attainment of improved particle shapes and increased uniformity in size.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. An apparatus for forming metal powder comprising means forming a downwardly extending discharge passage for molten metal, said means having an outer surface and an annular downwardly and outwardly inclined lower end surface communicating at substantially the center of the upper end thereof with the discharge end of said passage and intersecting said outer surface at the lower end thereof to form an outer edge, and a nozzle unit formed with an annular downwardly and outwardly inclined lower end disposed in concentric relationship relative to said annular surface, said nozzle unit formed with an internal annular wall defining a first annular chamber disposed in communication with said annular aperture and a second annular chamber radially spaced from said first annular chamber, a plurality of ports formed in said annular wall providing for communication between said first and said second annular chambers, and supply means for introducing a pressurized stream of gas into said second annular chamber in a direction substantially tangential relative to said annular wall imparting circular movement to the stream of gas in said second chamber and passage thereof through said ports into said first annular chamber and discharge therefrom through said annular aperture in the form of a downwardly extending converging vortex directed across said outer edge of said inclined surface for drawing molten metal out of the lower end of said discharge passage and along said inclined surface and effecting atomization thereof at said outer edge.

2. An apparatus for forming metal powder comprising means forming a downwardly extending discharge passage for molten metal, said means having an outer surface and an annular downwardly and outwardly inclined lower end surface communicating at substantially the center of the upper end thereof with the discharge end of said passage and intersecting said outer surface at the lower end thereof to form an outer edge, and a nozzle unit formed with an annular downwardly and inwardly directed aperture disposed in concentric relationship relative to said annular surface, said nozzle unit formed with an internal annular wall defining a first annular chamber disposed in communication with said annular aperture, and a second annular chamber radially spaced from said first annular cham-

5

ber, said annular wall formed with a plurality of ports disposed in substantially equal circumferentially spaced increments and oriented in a direction substantially tangential to said first and said second annular chambers providing for communication therebetween, supply means 5 for introducing a pressurized stream of gas into said second annular chamber in a direction substantially tangential relative to said annular wall imparting circular movement to the stream of gas in said second annular chamber and passage thereof through said ports into said 10 first annular chamber and discharge thereof from said annular aperture in the form of a downwardly extending converging vortex directed across said outer edge of said inclined surface for drawing molten metal out of the lower end of said discharge passage and along said inclined sur- 15 face and effecting atomization thereof at said outer edge.

6

References Cited by the Examiner

UNITED STATES PATENTS

1,856,679	5/1932	Williams et al.
2,968,062	1/1961	Probst et al.
3,004,719	10/1961	Pouppirt.

FOREIGN PATENTS

33,423	10/1921	Norway.
--------	---------	---------

10 ROBERT B. REEVES, *Primary Examiner*.M. HENSON WOOD, JR., *Examiner*.R. S. STROBEL, *Assistant Examiner*.