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APPARATUS FOR THE PREPARATION OF METAL POWDER

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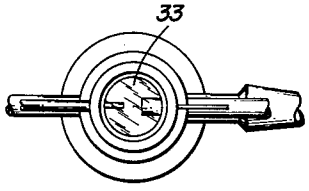


FIG. 2

FIG. 1

INVENTORS
ERWIN A. LEZBERG
ALBERT M. LORD

BY R. J. Tompkins
ATTORNEYS

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APPARATUS FOR THE PREPARATION OF METAL POWDER

Erwin A. Lezberg, Lakewood, and Albert M. Lord, Olmsted Falls, Ohio, assignors to the United States of America as represented by the Secretary of the Navy

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This invention relates to the preparation and collection of oxide free metal powder, of extremely small particle size.

There are several methods in use for production of fine metal powders, such as atomization of molten metal in heated gas jets, the formation of an electric arc in a liquid between the metal in wire form and an adjoining electrode, mechanical disintegration by means of ball, roller or hammer mills or attrition, condensation of metal vapor, or electrolytic reduction. However, it has been found that metal particles derived from the prior methods fail to meet requirements as to extreme fineness and freedom from oxidation so that the required product is unobtainable from known commercial sources.

The primary object of the invention, therefore, is to provide a source of metal particles which are free of oxidation. Another object is to provide a method of producing metal particles of the described type which is simple in operation. Still another object is to provide a method for fine metal powder production which is subject to easy control of the particle size. Other objects and features of the invention will appear on consideration of the following description of the method and apparatus used, as illustrated in the accompanying drawings, in which:

Fig. 1 is a schematic view of the apparatus employed in the method; and

Fig. 2 is a detail of the structure of Fig. 1 taken along lines 2—2 of Fig. 1.

Generally stated, the method found to meet the stated requirements involves fusion of the metal in wire form by an electric arc in an inert atmosphere with appropriate conveyance of the condensed metal droplets to a receptacle.

In Fig. 1, the apparatus may be examined in three major units, the wire feed equipment **10**, the electric arc unit **11** and the receptacle **12**. The wire feed equipment is adapted bodily from the electric welding art and comprises a feed mechanism **15**, driven by motors **16** and **17**, passing wire **18** through guide tube **19** to the arc unit **11**, all under control of the control unit **20**. This feed equipment is arranged to feed the wire, which may be magnesium, aluminum or any desired metal substance, into an open electric arc at a constant arc voltage, automatic controls maintaining adequate electrode spacing for this purpose after initial electrode contact. Such equipment is currently manufactured and sold in the open market. (For example, products of The Auto Arc-Weld Manufacturing Co., Cleveland, Ohio, and Patent 2,516,777.)

The electric arc unit **11** includes a vertically positioned tube **30** serving as a gas chamber for inert gas flow and as a support for the arc electrodes. The upper tube end is closed by a cap **31** in the end of which is attached a sight tube **32** terminating in a glass window **33** through which the arc terminals in tube **30** may be visually examined.

The base of tube **30** is closed by a cap **34** which at its lower end converges into the exit pipe connection **35**. A cooling chamber is formed about tube **30** by the shell **36** inlet duct **37** connecting at the base of the shell and

outlet duct **38** connecting at the top thereof. Valve **39** in inlet **37** permits control of the coolant flow.

The two arc electrode holders are horizontally disposed about midway in the tube **30** and shell **36**. The wire electrode holder **40** is a tube with one end attached to, and having egress into, tube **30**. At the other end of the holder tube **40** is attached to a three way T coupling **41**, the outlet of which in line with tube **40** being connected to, and supporting within tube **40**, a refractor tube **42** of crystallized alumina, such as Alundum. Tube **42** projects at its outer end **43** a short distance beyond coupling **41** and at its inner end **44** a short distance into tube **30**, and serves as a guide and holding sleeve for the wire **18** when threaded therethrough. The space between tubes **40** and **42** at the inner ends thereof is open to permit free passage of gas to the arc space.

The opposed electrode holder **50** is also a tube transversely penetrating the walls of tubes **30** and **36** at points in axial alignment with tube **40**, with the inner end flush with the wall of tube **40** and the outer end extending a short distance beyond the wall of shell **36**. The outer end of tube **50** terminates in a bushing **51** forming an attachment means for the fixed electrode rod **52** to which the electrode **53**, enclosed by tube **50**, is attached. This electrode, which is preferably made of graphite, has an enlarged cylindrical head **53** extending about midway into the arc chamber. The outer end of the electrode rod **52** is secured to the terminal block **54** of cable **55** through which direct current electric power is obtained; and the corresponding power terminal block **56** for the wire is attached to the feed nozzle **57** of the wire feed unit **10**, the cable **58** connecting the block to the power source.

To prevent oxidation of the arc fused metal, inert gas, such as helium, argon and the like, is forced into the arc chamber of tube **30**. From any pressurized source this gas is led by conduit **61**, one end of conduit **61** connecting to the transverse outlet of T coupling **41** and the other end connecting directly to the sight tube **32** at the top of the arc chamber. Gas inflow at the sight tube insures clarity of view of the electrodes during the fusion step, the particle mist being swept downwardly by the gas movement. A pressure gauge **62** is connected to conduit **61** and a thermoelectric thermometer **63**, including gauge **64** and thermocouple **65**, gives arc chamber temperatures. Valve **66** in conduit **60** controls the gas flow.

The receptacle **12** for the metal particles is a flat based cup **70** with a transverse edge flange **71**, to which a flat cover plate **72** is attached, as by bolts **73**. About mid-depth in the cup, a perforated plate **74** of any inert material such as metal or plastic is secured, the function of this plate being to distribute the gas bubbles and scrub the metal particles from the gas stream. A central inlet pipe **75** passing through the cover plate **72** and perforated plate **74**, is suspended by a union **76** from the end of arc chamber pipe **35** so that its lower end is above the flat bottom of the receptacle. An exit pipe **77**, for the inert gas is attached to the closure plate **72**. Normally the receptacle contains an inert liquid **78** such as kerosene, to a depth covering the perforated plate **74**.

In operating the apparatus the coolant valve **39** and helium gas valve **66** are opened to insure in the arc chamber an air free atmosphere and a safe maintained temperature. Gas entering the T **41** moves along the annular space between the tubes **40** and **42** so that it sweeps the region of the arc. Gas entering by way of the sight tube **32** clears the upper chamber space for arc inspection through window **33**. Power switches are then closed to supply electric current to the wire feed unit **10** and to the arc circuit terminals **54** and **56**. The wire, which is assumed to be magnesium, is thus fed through

holder tube 42 until it contacts the fixed graphite terminal 53, whereupon the wire tip is withdrawn with the arc formed between the wire and graphite. The feed unit holds the arc at the point of constant potential in accordance with well known welding machine practice.

The current amperage is now adjusted until the wire tip is fused into small droplets, a current of around 260 amperes being suitable for a one-sixteenth inch diameter wire in a helium atmosphere. These droplets are condensed in the helium gas as a spray and swept toward the exit pipe 35, the receptacle pipe 75 and the receptacle liquid, the metal particles being wetted by the liquid and forming a suspension therein to be removed as desired. The gas, after discharging some additional particles by scrubbing action in the perforated plate 74, passes out through exit pipe 77.

It is noted that the fineness of the particles produced can be controlled by the current density of the arc. Below a given value for the metal mere fusion occurs, while above this value small particles develop as a fine spray. The feed rate is fixed by the arc voltage and may be adjusted as desired. Also, the arc length may be varied by setting the arc control, according to known methods. The particles produced are extremely fine, sizes ranging from one to five microns, and spherical in shape. Due to the immediate solidification of the particles there is no tendency to agglomeration and being free of oxidation, the particles are at once usable.

Modified procedures and equipment may also be employed, other than herein above described. For example, instead of the liquid bubbling of the particle laden gas use might be made of liquid scrubbing, electrostatic, centrifugal or canvas bag screening methods. Also, while magnesium is referred to as the metal, and helium the gas, any stable metal or inert gas may be used, the procedure involving a physical breakdown of the metal under certain conditions of electric arc density within an inert atmosphere to prevent oxidation. It is understood therefore that the invention may be practiced otherwise than as specifically described, within the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. Apparatus for producing metal particles of extreme fineness from wire of said metal, comprising an arc chamber, a source of electric current, a fixed electrode in said chamber, a wire in said chamber, electrically conducting means between said source and said wire and electrode, means for advancing said wire into arc forming relationship with said electrode, a receptacle for liquid and for particles derived from the formed arc, said liquid being inert to said particles, and means for passing said particles from said arc into said liquid without oxidation thereof, said particle passing means including a tube connecting said electrode and receptacle for passing pressurized inert gas from said electrode through said liquid.

2. Apparatus for producing metal particles as defined in claim 1 and means for channeling said gas at multiple points of flow through said liquid.

3. Apparatus for producing metal particles of extreme fineness comprising an electric arc chamber, a fixed electrode in said chamber, a wire mounted for movement into said chamber in arcing relationship to said electrode, a source of electric power for supplying arc current to said wire and electrode, a particle receptacle containing an inert liquid, a conduit extending from said arc chamber to a point displaced from the bottom of said receptacle, and means for forcing particles formed in the wire-electrode arc through said conduit and into said liquid without oxidation of said particles, whereby the particles are collected in said receptacle.

4. The apparatus for producing metal particles of extreme fineness as defined in claim 3, said particle forcing means including a gas connector tube between said chamber and receptacle, and additional means supported in said receptacle for dispersing the gas throughout the volume of said liquid.

5. Apparatus for producing metal particles of extreme fineness comprising an electric arc chamber, an electrode in said chamber, means for feeding a wire into arc producing relationship with said electrode, a source of electric current for arc formation between said wire and electrode, a receptacle for said metal particles, a conduit connecting said arc chamber and receptacle, means for forcing metal particles formed at said arc into said receptacle, and means for holding said arc chamber at an approximately constant temperature.

6. A method of producing metal particles of extreme fineness which comprises forming an electric arc between the metal in wire form and a fixed inert electrode, enveloping said arc in an inert gas, producing a current density at the arc of such value as to obtain disintegration of the wire in particle form, advancing said wire continuously while the wire is being disintegarated in said arc, and conveying all of said gas, laden with metal particles, through a liquid bath wherein the particles are suspended.

7. The method of producing metal particles as defined in claim 6 with the additional step of dispersing the gas flow in its movement through said bath.

8. The method of producing fine metal particles, which comprises forming an electric arc between the metal in wire form and an inert electrode, enveloping said arc in an inert gas, producing a current flow through said arc of such value as to disintegrate the metal to fine particles, conveying said particles and all of said gas to a liquid receptacle, and wetting said particles in said liquid.

9. The method of producing fine metal particles as defined in claim 8, said current having a value of around 260 amperes for one-sixteenth inch diameter magnesium wire in a helium atmosphere.

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