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Clark

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[54] **METHOD FOR POWDER METAL PRODUCTION**

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Related U.S. Application Data

[63] Continuation of Ser. No. 55,123, July 15, 1970, abandoned.

[52] **U.S. Cl.** **264/8;** 264/10

[51] **Int. Cl.** **B22f 9/00**

[58] **Field of Search** 264/12, 10, 25, 8

[56] **References Cited**

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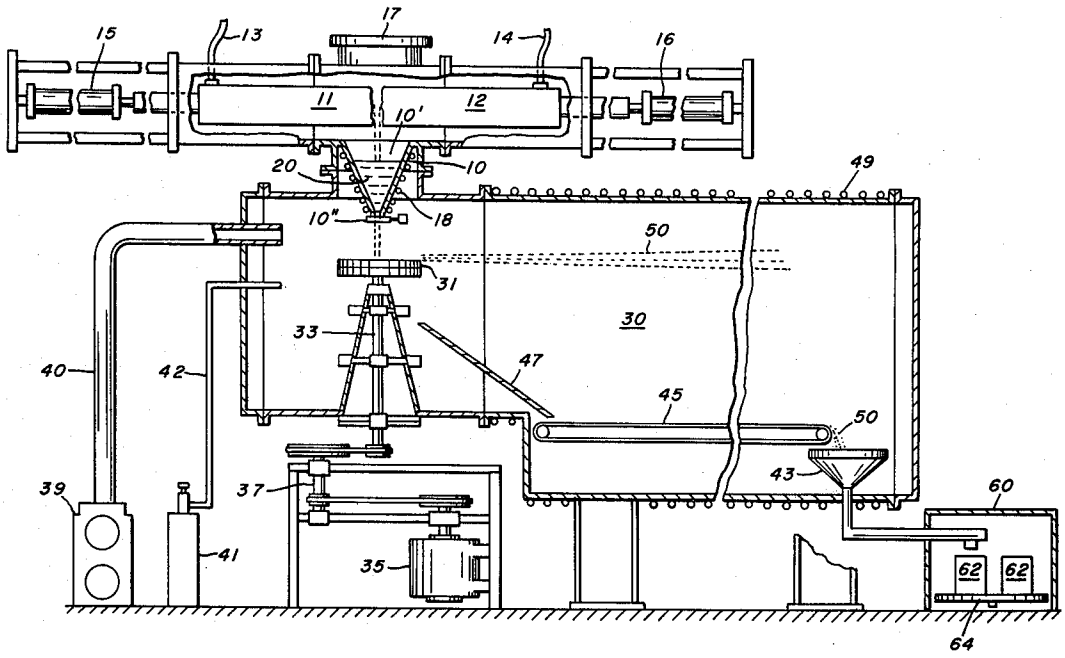
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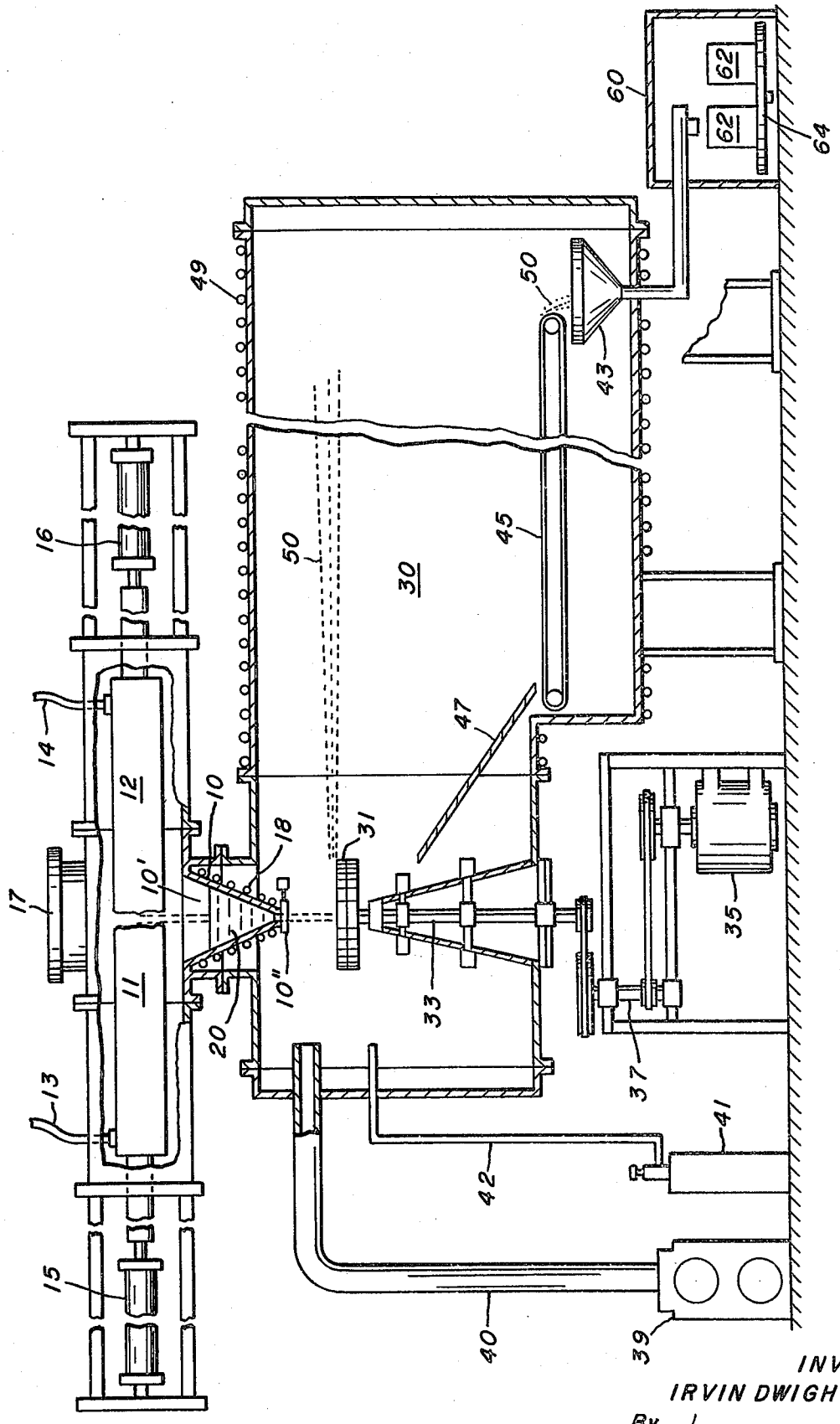
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[57] **ABSTRACT**

A method for producing pre-alloyed metallic powder which utilizes a pair of electrodes and a reservoir to accomplish its objectives. An arc is struck between a consumable electrode and a second electrode to produce molten metal which is collected, held and homogenized in a reservoir and subsequently atomized.

5 Claims, 1 Drawing Figure





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METHOD FOR POWDER METAL PRODUCTION

This is a continuation of application Ser. No. 55,123, filed July, 15, 1970, now abandoned.

The present invention relates to a method of producing powder and more particularly to a method of producing pre-alloyed metallic powder.

Design applications frequently require alloys which will not fail at elevated temperatures; e.g., 1,700°F, under relatively high stresses; e.g., 15 ksi. Alloys which meet the requirements are referred to as superalloys. An exemplary superalloy consists essentially of, in weight percent, up to 0.18% carbon, from 14.2 to 20% cobalt, from 13.7 to 16% chromium, from 3.8 to 5.5% molybdenum, from 2.75 to 3.75% titanium, from 3.75 to 4.75% aluminum, up to 4% iron, from 0.005 to 0.035% boron, up to 0.5% zirconium, balance essentially nickel with incidental impurities. Many other superalloys are described in various technical publications.

Superalloys are often desired in small and/or complex shapes. These shapes are most economically produced by powder metallurgy techniques. To produce optimum mechanical properties in powder metallurgy manufactured products it is often desirable to use prealloyed powder, i.e., powder that has each element present in each particle in substantially equal amounts.

Metallic powder has been produced from consumable electrodes. Certain prior practices comprised the striking of an arc between a metallic consumable spinning electrode and a tungsten electrode and others comprised the striking of an arc between a metallic consumable electrode and a spinning wheel. A particular prior art process is disclosed in U.S. Pat. No. 2,897,539 issued on Aug. 4, 1959. The process disclosed therein is disadvantageous insofar as it requires a starter body to protect the rotating table from damage caused by the arc and to preclude contamination of the powder being produced. In addition, it is plagued by a troublesome sliding electrical contact to the rotating table.

I have determined that the prior art consumable electrode melting processes for producing metallic powder, such as the process disclosed in U.S. Pat. No. 2,897,539, are not suitable for the production of prealloyed superalloy metallic powder as superalloy consumable electrodes have a segregated; i.e., heterogeneous, makeup. Superalloy consumable electrodes have a concentration of low melting point impurities, elements and compounds in their center and form metal droplets of varying composition when melted. The grains of consumable electrodes grow inward during their solidification and drive the low melting point impurities, elements and compounds along with them, thereby setting up a degree of segregation within the electrodes. This degree of segregation is more prominent in superalloys than in other alloys as superalloys have a greater difference between their liquidus and solidus temperatures and since superalloys are statically cast.

The present invention provides a method for producing pre-alloyed metallic powder and utilizes a pair of consumable electrodes and a reservoir; e.g., a tundish, to accomplish its objectives. Use of a pair of electrodes removes the need for an electrical connection to the rotating table which obviates the troublesome sliding electrical contact and eliminates the requirement of a starter body to protect the rotating table from damage caused by the arc and to preclude contamination of the powder being produced. In addition, the double electrodes improve melting efficiency when both are consumable. The reservoir provides a means for holding a homogenizing molten metal prior to atomization.

It is accordingly an object of this invention to provide a method for producing pre-alloyed metallic powder.

The foregoing and other objects of the invention will be best understood from the following description, reference being had to the accompanying drawing wherein:

The Figure is a schematic view of an embodiment of the apparatus for producing pre-alloyed powder from consumable electrodes.

The method of the present invention comprises the steps of melting a metallic consumable electrode by striking an arc between it and a second electrode (the second electrode can be consumable or nonconsumable; e.g., a tungsten electrode), collecting the molten metal from the consumable electrode or electrodes in a heated reservoir, holding the molten metal in the reservoir for a period of time sufficient to homogenize it, passing the homogenized molten metal from the reservoir, atomizing the homogenized molten metal into powder and collecting the powder. Atomization can be performed in the air but is preferably performed in a non-reactive atmosphere such as an inert atmosphere; e.g., argon, or a vacuum. Illustrative methods of atomization comprise the steps of passing the homogenized molten metal onto a moving disintegrator or into an inert gas stream.

The apparatus used to perform the method of the present invention is best seen from the Figure which is a schematic view of a particular embodiment of the invention. It comprises reservoir or tundish **10**, having an inlet **10'** and outlet valve **10''**, which holds and homogenizes molten metal **20**, supplied from consumable electrodes **11** and **12** (either electrode could have been nonconsumable), electrical connections **13** and **14** for striking an arc between electrodes **11** and **12**, hydraulic pressure cylinders **15** and **16** for moving electrodes **11** and **12** together, sight port **17** for viewing the arc between electrodes **11** and **12**, resistance heater **18** for supplying heat to molten metal **20** in tundish **10**, atomization chamber **30**, disintegrating wheel **31** for atomizing the molten metal (an inert gas stream or a vibrating disintegrator could have been used), shaft **33** for imparting motion to disintegrating wheel **31** through motor **35** and speed increaser **37**, vacuum pump **39** and inert gas source **41** for producing a nonreactive atmosphere in atomization chamber **30** through conduits **40** and **42**, hopper **43** for collecting metallic powder **50**, moving belt **45** for carrying metallic powder **50** into hopper **43**, shield **47** for directing metallic powder **50** onto belt **45**, cooling coils **49** to dissipate heat from powder **50** and atomization chamber **30** so as to keep particles from adhering to each other, container chamber **60**, containers **62** for receiving powder from hopper **43** and turntable **64** for holding and placing empty containers below hopper **43**.

In operation the relative position of consumable electrodes **11** and **12** is adjusted, through hydraulic pressure cylinders **15** and **16**, to obtain proper spacing for the passing of an electrical arc. Current is passed through electrical connections **13** and **14** in order to strike an arc and melt the electrodes. Proper spacing of consumable electrodes **11** and **12** is maintained

through hydraulic pressure cylinders **15** and **16** as the electrodes are consumed. The character of the arc is observed through sight port **17.** Molten metal from the electrodes is collected through inlet **10'** and held in tundish **10** for a period of time sufficient to homogenize it. A nonreactive atmosphere is created in atomization chamber **30** through conventional means utilizing vacuum pump **39** and conduit **40** or vacuum pump **39,** conduit **40,** inert gas source **41** and conduit **42.** Motion is imparted to disintegrating wheel **31** from motor **35** through speed increaser **37** and shaft **33.** Molten metal is atomized into metallic powder by being passed from tundish **10,** through outlet valve **10''**, onto disintegrating wheel **31** (outlet valve **10''** is positioned at mid-radius with respect to wheel **31** so as to give the powder particles proper directional motion, as depicted in the Figure). Metallic powder is carried to hopper **43** by moving belt **45** and passed through hopper **43** into collecting containers **62.**

From the above paragraphs it will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific examples thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they should not be limited to the specific examples described herein.

I claim:

1. A method of producing metallic powder of a superalloy wherein each element in the alloy is present in each particle of powder in substantially equal amounts, which comprises the steps of: arranging a statically cast superalloy consumable electrode having a heterogeneous make-up in a substantially horizontal position; arranging a second electrode in a substantially horizontal position; melting said consumable electrode by striking an electric arc between it and said second electrode; collecting molten metal droplets from said consumable electrode in a heated reservoir, said droplets having varying compositions; holding said molten metal in said reservoir for a period of time sufficient to homogenize it; passing said homogenized molten metal from said reservoir; atomizing said homogenized molten metal and cooling it to a temperature below its melting point as it passes from said reservoir, thereby forming metallic superalloy powder, each particle of powder containing each element in said alloy in substantially equal amounts; and collecting said powder, said powder being processable into parts having excellent high temperature strength.

2. A method according to claim **1** wherein said atomizing comprises the step of passing said homogenized molten metal onto a moving disintegrator.

3. A method according to claim **1** wherein said atomizing is performed in a nonreactive atmosphere.

4. A method according to claim **1** wherein said second electrode is a metallic consumable electrode.

5. A method according to claim **2** wherein said moving disintegrator is a wheel and wherein said molten metal contacts said wheel off-center thereof.

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