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Clark

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[54] **APPARATUS FOR COATING PARTICULATE MATERIAL**

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[52] **U.S. Cl.** **118/49.1**

[51] **Int. Cl.** **C23c 13/12**

[58] **Field of Search** ..... 118/48–49.1; 117/93.3; 222/414, DIG. 1

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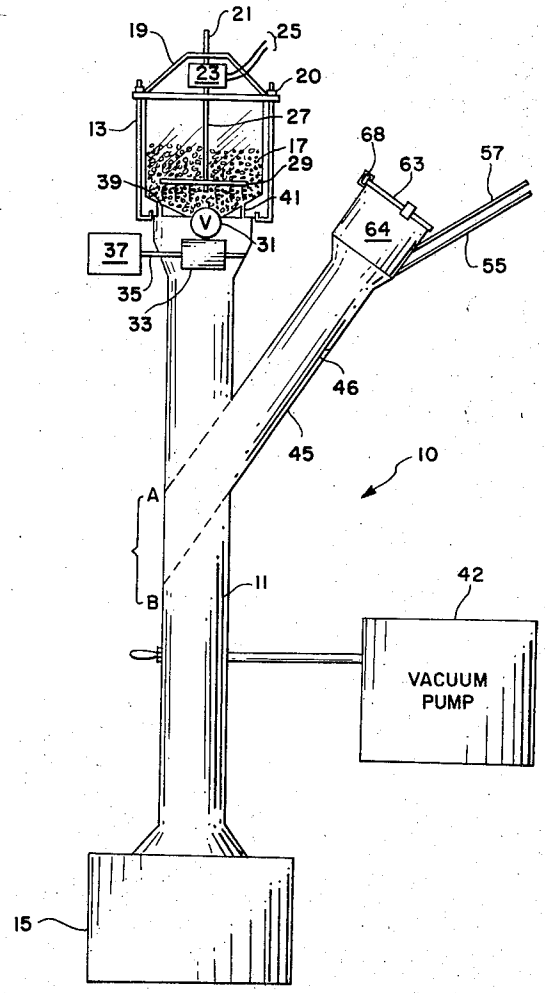
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[57] **ABSTRACT**

Apparatus and method of depositing controlled thickness coatings on small particles including a drop tower for gravity feed of the particles from a first hopper to a second hopper and wherein the particles are induced to spin during fall and pass through a vaporized coating medium; said medium comprising an ion beam directed from an ion emitter disposed laterally offset from, and shielded with respect to, said drop tower.

10 Claims, 2 Drawing Figures



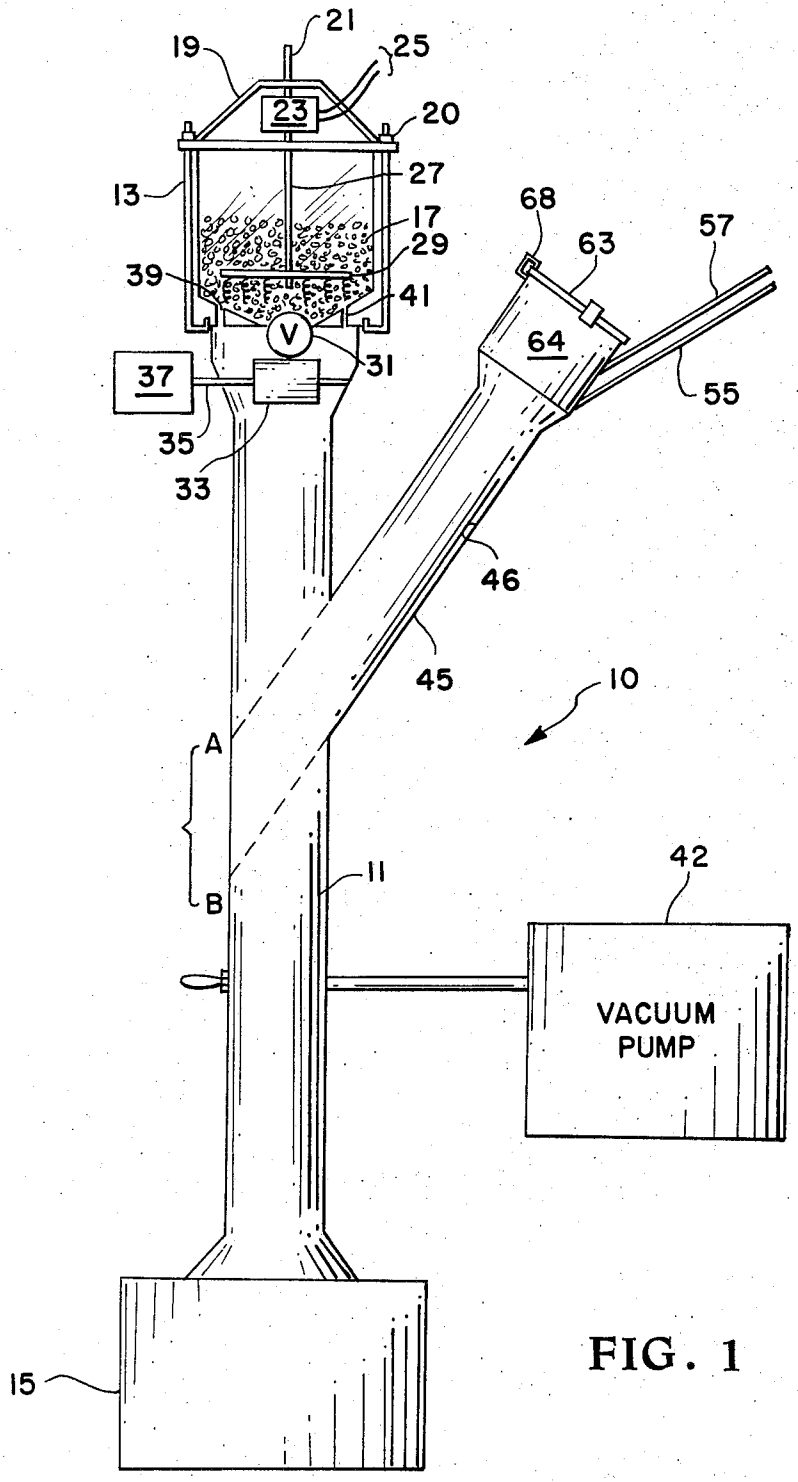

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FIG. 1

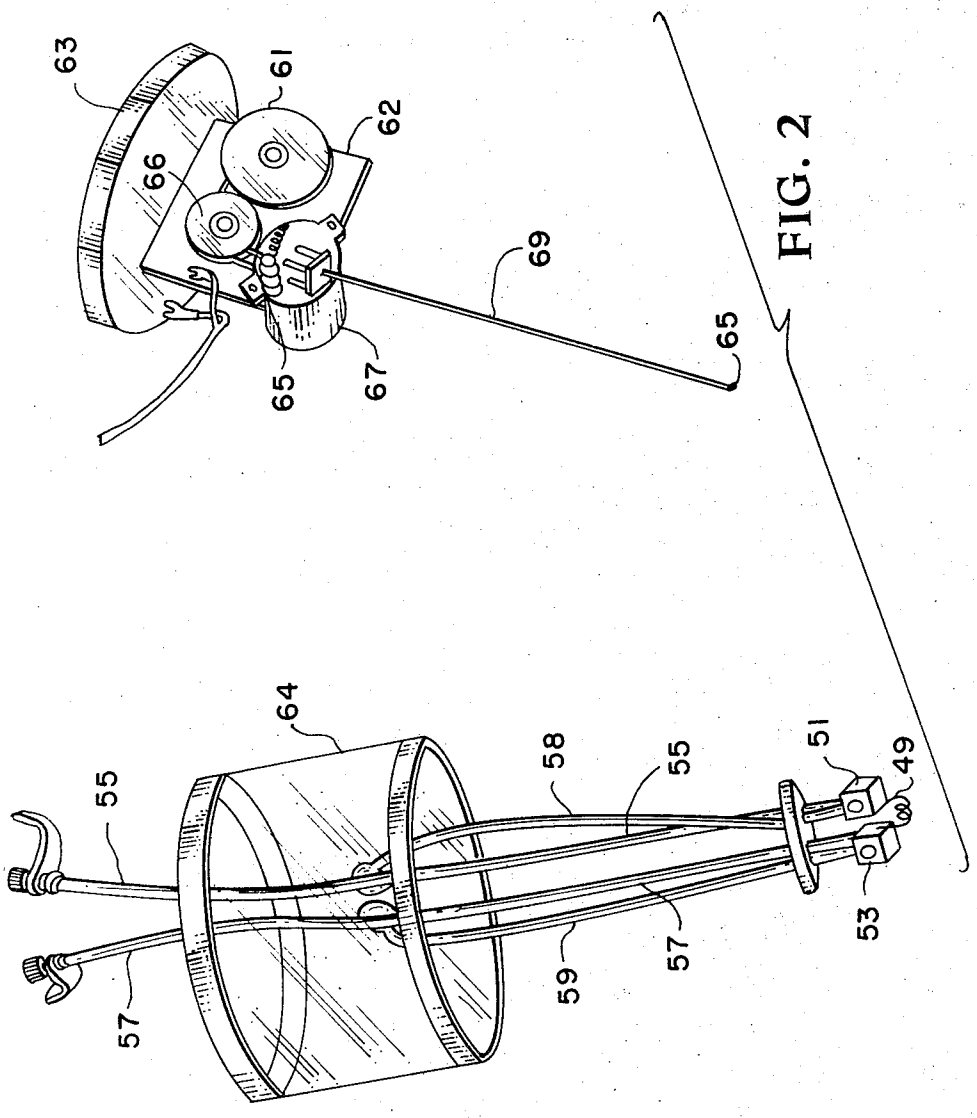


FIG. 2

APPARATUS FOR COATING PARTICULATE MATERIAL

ORIGIN OF THE INVENTION

This invention was made by an employee of the National Aeronautics and Space Administration and may be manufactured and used by or for the government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention is concerned with an apparatus for applying thin controlled thickness coatings on small particles. Controlled thickness coatings on many small particles such as glass spheres, chopped strands of fiberglass, solid granules of propellant fuels, and the like, have proved of increasing importance in ordnance and aerospace research projects. For example, metallic coated filled and hollow glass spheres have been employed in sandwich structures, ablative shielding compositions, and the like, as filler material to control the density of the compositions and to alter the other properties thereof. Similarly, coated propellant fuel granules are employed in various propellant compositions. Some of the known processes for applying coatings to small particles have required increased temperature environments for the coating step and the thickness of the coating applied has been difficult to adjust with uniformity and accuracy.

It is therefore an object of the present invention to provide a novel apparatus for coating small particles with a uniform coating material.

Another object of the present invention is an apparatus for applying a fusible coating material to small particles.

Another object of the present invention is to provide an apparatus for uniformly coating small particles in an ambient temperature environment.

Another object of the present invention is to provide an apparatus for applying a uniform fusible coating to small particles under vacuum conditions.

BRIEF SUMMARY OF THE INVENTION

According to the present invention, the foregoing and other objects are attained by providing a vertically disposed drop tower having a feeder hopper at the upper end thereof, a collection hopper at the lower end and a coating chamber area intermediate the ends of the tower. The feeder hopper contains a quantity of small granular particles to be coated and is provided with a valve for releasing the particles at a controlled rate for free fall through the coating chamber into the collection hopper. A motor-driven stirrer serves to break up any clumps of material which may form in the hopper and provides a steady supply of the granular material at the bottom of the hopper. A high speed rotating drum having a knurled surface is provided near the top of the tower and adjacent the exit valve of the feeder hopper. This drum receives the granular material exiting the feeder hopper and effectively scatters the material further destroying particle clumps and allows the material grains to fall individually through the tower. An additional and more important purpose of the drum is to impart a spinning motion to the particles so that they will be completely coated as they pass through the deposition beam.

An ion beam is contained in a separate Y-branch to the main apparatus so as to be optically shielded from the coating chamber. In addition, by positioning the ion emitter a distance from the coating chamber the coating process is conducted in a relatively cold environment. The entire drop tower is maintained under a suitable vacuum during the coating process.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the inherent advantages thereof will be more clearly understood by reference to the following detailed description when considered with the accompanying drawings wherein:

FIG. **1** is a part sectional, part schematic representation of the coating apparatus according to the present invention; and

FIG. **2** is a part exploded view of the ion emitter assembly of the present invention.

DETAILED DESCRIPTION

Referring now to the drawings and more particularly to FIG. **1** there is shown the coating apparatus of the present invention generally designated by reference numeral **10.** Coating apparatus **10** includes a vertically disposed drop tower **11** having a feed hopper **13** attached to the upper end thereof and a collection hopper **15** connected to the lower end thereof. Feed hopper **13** is adapted to receive a quantity of granular material **17** therein that is to be coated in drop tower **11.** A cover **19** is provided for feed hopper **13** and is attached thereto in hermetically sealed relationship by a plurality of bolted clamps, one of which is designated by reference numeral **20,** in a conventional manner.

Cover **19** is also provided with a vertical extension **21** to serve as an attachment for a support clamp or the like, not shown, for stabilizing coating apparatus **10** during a coating operation. A small electric motor **23** having leads **25** connected to a suitable current source (not shown) is provided in cover **19** and serves to rotate a shaft **27** at a controlled rate. A stirring mechanism **29** is secured to shaft **27** and serves to prevent clumping of the granular particles **17.** In the embodiment illustrated stirring mechanism **29** is in the form of a horizontal bar with a plurality of dependent spring segments integrally attached thereto. Other conventional stirring apparatus may be employed as so desired.

An exit valve **31** is disposed at the base of feed hopper **13** and is manually or other selectively controlled to meter the flow of granular particles **17** into drop tower **11.** As the particles **17** leave valve **31** they contact a rotating drum **33** and are scattered thereby. A shaft **35** leading to a suitable electric motor **37** serves to rotate drum **33** at a controlled speed during a coating operation. Drum **33** is provided with a knurled surface with the knurling grooves being approximately 100 times as large as the particles **17.** The primary purpose of drum **33** is to scatter the granular material to further destroy any particle clumps and to impart a spinning motion to the individual particles so that they will become completely exposed to the deposition beam as they pass through the coating medium.

A plurality of vacuum ports, two of which are shown in FIG. **1** and designated by reference numerals **39** and **41,** provide further communication between feed hopper **13** and drop tower **11** to permit the entire appara-

tus to be subjected to vacuum conditions by a suitable vacuum pump as schematically represented by block **42.** Vaccum pump **42** serves to maintain apparatus **10** at a pressure of approximately 10^{-6} mm Hg where linear streaming of the deposition material occurs. A suitable ion vacuum gage, not shown, is built into the apparatus in order to monitor the pressure.

The ion beam is contained in a separate Y-branch **45** to the drop tower **11** with a suitable optical shielding **46** being provided thereon to optically shield the ion beam from the main portion of the tower **11.** As a result, the coating material is forced to follow a longer and more linear path before reaching the area designated by dotted lines A-B where the grains of material to be coated are exposed to the ion beam. In addition to providing a more even coating, this arrangement allows the placement of the hot, emitting electrode far enough away from the coated particles to preclude damage to the particles from heat to thus insure that the coating process takes place in an essentially cold environment.

The filament arrangement shown more particularly in FIG. **2** is easily adaptable to a continuous, precisely controlled operation. The ion beam is generated by an electrically heated high vacuum tungsten filament, designated by reference numeral **49** and connected between two cooled electrodes designated by reference numerals **51** and **53.** The water inlets for electrodes **51** and **53** are designated, respectively, by reference numerals **55** and **57** while the outlets are designated, respectively, by reference numerals **58** and **59.** A bar of the material to be deposited is stored on a spool **61** attached to a dependent bracket **62** extending from cover **63** for the ion beam container **64.** In operation, cover **63** and its attachments are fastened to container **64** by a plurality of clamps **68.**

The bar material **65** passes over a free turning pully **66** and is threaded through an electric drive motor **67** into a tubular guide **69** leading to the vicinity of filament **49.** In operation, the filament **49** is operated by a suitable current source leading through water inlets **55** and **57** of such intensity as to maintain filament **49** at a white heat with enough of the deposition bar **65** being melted so that filament **49** remains tinned by the deposition material. Motor **67** is selectively controlled to insure the deposited bar material is present adjacent filament **49** in the solid, liquid and gaseous phases simultaneously. The rate of evaporation of deposition material **65** is controlled by the temperature of filament **49,** which can be adjusted in a conventional manner to precisely determine the rate of deposition by adjusting the filament voltage.

Apparatus **10** is normally operated at a pressure of 10^{-6} mm Hg where linear streaming of the deposition material will occur in branch **45.** A suitable ion vacuum gage, not shown, is built into the apparatus in order to monitor the pressure.

Apparatus **10** described hereinbefore has been used successfully to deposit a metallic coating on small hollow glass spheres sold under the trade name of Eccospheres. These glass spheres are available in a number of sizes ranging from 3 microns to 1,000 microns in diameter. Solid small particulate material, such as propellant powder grains, glass balls, shot and the like having diameters of at least one-half inch may also be coated with the apparatus described herein. Coatings obtained using the one ion gun shown in the illustrated embodiment have normally been approximately 200 angstroms thick under conditions where the particles fell through a beam of 8–10 centimeters long as designated by area A-B in FIG. **1.** Additional ion guns could be readily employed in separate Y branches where additional thickness is desired. Each gun would deposit approximately 200 angstroms of coating material or more if the size of the gun is also scaled up and depending on the temperature. For example, a larger gun operating at the same temperature or a gun of the same size operating at a higher temperature would deposit a thicker coating.

Any suitable and conventional coating material may be employed in the present invention. As illustrated, metallic bar material having a diameter range of 0.0002 – 0.030 inches is readily adaptable for dispensing via spool **61.** Metals such as gold, silver, copper and aluminum are particularly useful with the present invention although other metals and fusible nonmetals are equally applicable dependent upon the end use envisioned for the particulate material to be coated. There are obviously many modifications and variations of the present invention possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for depositing a uniform thickness metallic coating on granular material comprising:

a. a vertically disposed drop tower;

b. a feed hopper attached to the top of said tower and a hopper attached to the bottom of said tower;

c. stirring means disposed in said feed hopper to prevent clumping of the granular material contained therein;

d. an exit valve connecting said feed hopper to said tower and serving to control the rate of flow of the granular material from said feed hopper to said tower;

e. means disposed in said tower adjacent said exit valve for scattering the granular material passing through said valve and to impart a spinning motion to the individual granules comprising a rotating drum, said rotating drum having knurled grooves to isolate individual granules from each other and assist in destroying any particle clumps that may have passed through said exit valve and thereby permit the material grains to fall individually through said coating chamber on the way to said collection hopper;

f. a coating chamber within said tower and substantially intermediate said feed hopper and said collection hopper, and

g. means connected to said coating chamber to provide a coating medium for the individual granules as they pass through said coating chamber comprising an ion beam contained within a separate Y branch to said drop tower, an ion emitter from which said beam is directed and optical shielding to shield the ion emitter from the major portion of said drop tower.

2. Apparatus as in claim **1** wherein said stirring means consist of an electrically operated stirring mixer.

3. The apparatus of claim **1** wherein said ion emitter includes an electrically heated high vacuum tungsten filament having water-cooled electrodes, a bar of the

metallic material to be deposited being driven against said filament by an electric motor drive mechanism whereby as the deposition bar metal is melted the filament will be tinned by the deposition material and the deposited material will thus be present simultaneously in the solid, liquid and gaseous phases.

4. The apparatus of claim **3** including means for controlling the rate of deposition material evaporation.

5. The apparatus of claim **1** including a vacuum system in operative connection with said feeder hopper and said collection hopper capable of maintaining an operable pressure of at least 10^{-6} mm Hg where linear streaming of the deposition material occurs in said coating chamber.

6. The apparatus of claim **4** wherein the deposition metal is selected from the group of metals consisting of gold, copper, silver, aluminum and indium.

7. The apparatus of claim **4** wherein the granular particles coated are spherical in shape.

8. The apparatus of claim **7** wherein the spherical particles are hollow glass spheres having a size of 3 microns to ½ inch diameter.

9. The apparatus of claim **7** wherein the coating chamber is an area of from 8 to 10 centimeters' length in said drop tower.

10. The apparatus of claim **9** wherein the coating applied to said glass spheres is approximately 200 angstroms thickness.

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