Oct. 26, 1965 W. C. JENKIN 3,213,827

APPARATUS FOR GAS PLATING BULK MATERIAL TO METALLIZE THE SAME

Filed March 13, 1962 4 Sheets-Sheet 1

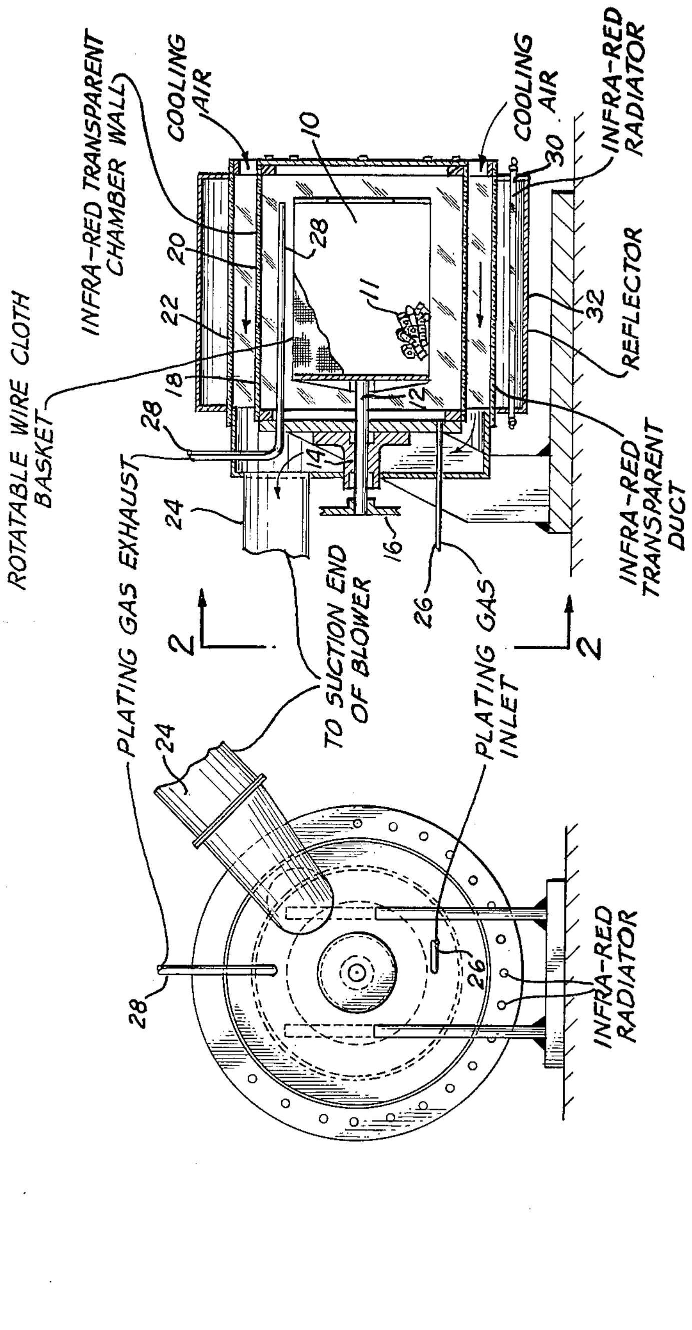

Fig. 1

Fig. 2

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Filed March 13, 1962 4 Sheets-Sheet 2

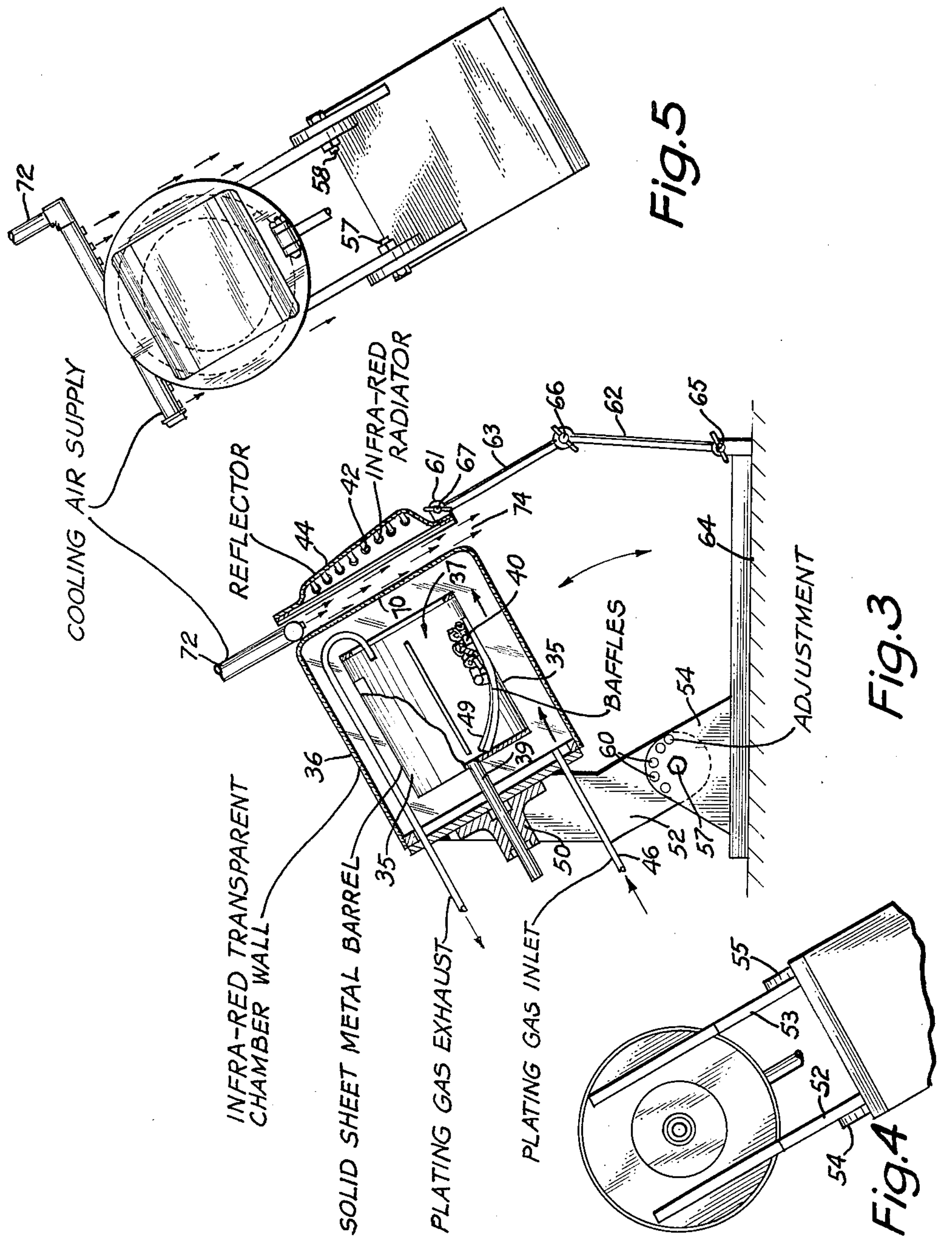

Fig.5

Fig.3

Fig.4

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APPARATUS FOR GAS PLATING BULK MATERIAL TO METALLIZE THE SAME

Filed March 13, 1962 4 Sheets-Sheet 3

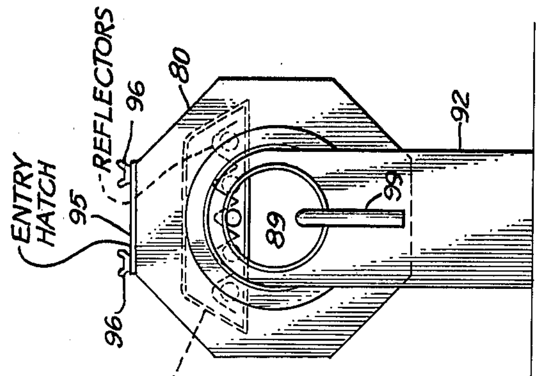

Fig. 7

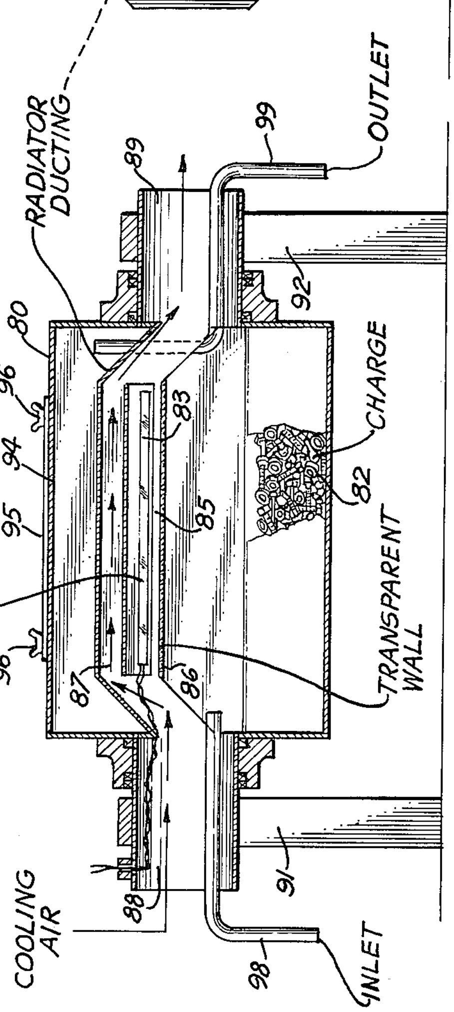

Fig. 6

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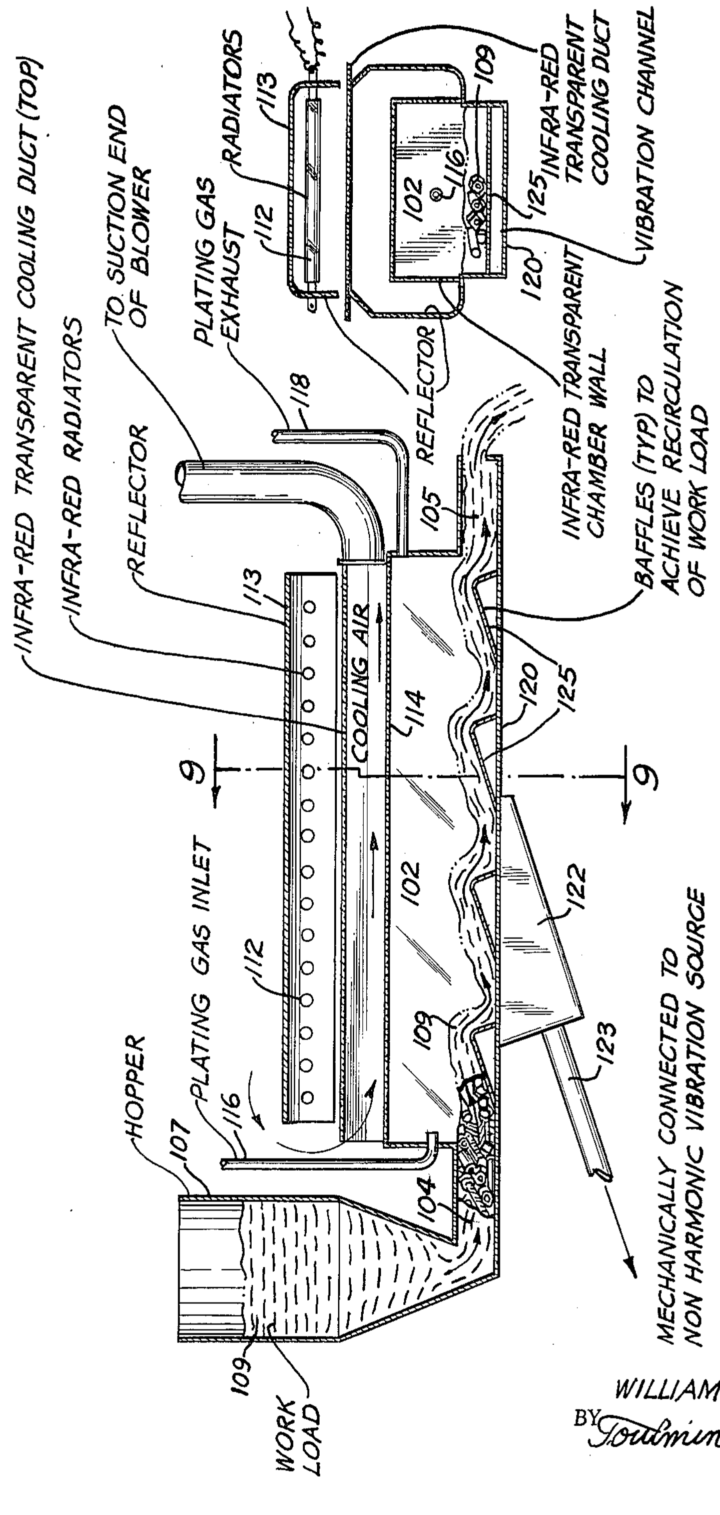

Fig. 9

Fig. 8

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APPARATUS FOR GAS PLATING BULK MATERIAL TO METALLIZE THE SAME

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1 Claim. (Cl. 118—49.5)

This invention relates to the plating of bulk materials or aggregates, and more particularly to metallizing articles or particles in bulk form by thermal decomposition of vapors of metal compounds, and such as now commonly referred to as "gas plating."

Heretofore, so-called barrel-type plating has been used for wet electroplating of bulk materials. This involves placing the material to be plated in a barrel or the like container, and immersing the same in electroplating solution, then tumbling the material about by rotating the barrel, the latter and the material therein being made the cathode with passage of electricity through the solution.

Such prior plating methods, however, are not applicable to gas plating employing thermally decomposable metal compounds because the problems involved are entirely different. Use of aqueous salt solutions and electrodes connected to pass direct electric current through an electroplating solution in which the article to be plated is placed as requisite for electroplating, is not utilized in gas plating. Aside from this principal difference, many other problems are involved in connection with the selection and handling of plating gases under controlled heating and requisite atmospheric conditions to bring about thermal decomposition of the plating gas and deposition of the metal coating on the substrate surface.

The present invention overcomes these difficulties and provides an efficient apparatus and method for plating solid particles of various shapes and sizes in bulk, evenly and uniformly. The parts or particles are thus metallized.

It is the principal object of this invention to provide an apparatus and method for accomplishing the gas plating of materials in bulk or aggregate form as described.

In accordance with this invention, it has been found, after considerable experimentation, that gas plating of metal deposits on the surface of bulk or aggregate material is achieved by utilizing a rotatable barrel within a vapor tight chamber or vessel having side walls or wall portions which are transparent to infrared rays and which are used for heating the work being gas plated. To provide for even and uniform heating of the bulk material or work load to be plated and tumbling within the chamber, infrared radiators are disposed about the chamber and operated to radiate heat through the transparent walls thereof and onto the work load whereby the same is heated to the requisite temperature for effecting gas plating.

In the practice of the invention, the work load is disposed in a barrel within a chamber having walls or portions thereof which are transparent to infrared light waves and the articles tumbled about, by rotation of the barrel, while the work load is retained in contact with a thermally decomposable metal compound. The work load is heated by infrared light waves to a temperature to cause the metal compound to thermally decompose and deposit metal evenly on the article.

In an alternate version, the chamber itself rotates but is non-transparent to infrared, the infrared radiators are located within the barrel and within an air-cooled infrared transparent duct.

Suitable apparatus for carrying out the gas plating of

bulk material is illustrated in the drawings accompanying and made a part of this specification.

In the drawings:

FIGURE 1 is a view in vertical section taken through a rotatable wire cloth basket container for carrying out gas plating;

FIGURE 2 is an end elevational view taken along the lines 2—2 of FIGURE 1, and looking in the direction of the arrows;

FIGURE 3 is a vertical sectional view taken through a modification of the gas plating apparatus illustrated in FIGURE 1; this employs a tipped-non-perforated barrel and is intended for aggregates that would not be retained on a wire cloth barrel. The infrared radiators direct heat through one end of the chamber and barrel;

FIGURES 4 and 5 are end elevational views of the apparatus illustrated in FIGURE 3, certain parts being broken away, and as viewed at the left and right side respectively;

FIGURE 6 is a vertical sectional view of another arrangement of rotatable gas plating apparatus comprising internally located infrared radiators within an infrared ray transparent duct; in this case, the rotatable barrel is airtight, preferably of metal, and is also the chamber wall;

FIGURE 7 is an end elevational view of the apparatus illustrated in FIGURE 6 and taken from the right side, as viewed in FIGURE 7;

FIGURE 8 is a vertical sectional view illustrating a further modification and which comprises a vibrated gas plating chamber, and illustrating diagrammatically the flow of solid bulk material therethrough by means of non-harmonic vibrations; and

FIGURE 9 is a sectional view taken substantially on line 9—9 of FIGURE 8, and looking in the direction of the arrows.

Referring to the drawings in detail, and FIGURES 1 and 2 in particular, the apparatus illustrated comprises a rotatable wire basket **10** for holding the bulk of material **11** to be metallized. The basket is supported on a shaft **12** which is mounted for rotation in a bearing element **14**, the shaft being driven by a motor, not shown, which is drivingly connected to the pulley wheel **16**.

The basket **10** is rotatably mounted in a plating chamber **18** which is provided with infrared transparent side walls **20**, the latter being surrounded by an air-cooled jacket **22**. To maintain the walls of the plating chamber at a lower temperature than the work load in the basket **10** and below the temperature which would cause the plating gas in contact therewith to decompose, relatively cool or low heated air is circulated through the cooling air jacket **22** as indicated by the arrows, to control the temperature of the wall surfaces. A blower, not shown, is connected at its suction end to the conduit **24** of the jacket **22**.

During gas plating, the thermally decomposable gaseous metal compound, preferably admixed with inert carrier gas, e.g., helium, argon, etc., is introduced into the plating chamber **18** through an inlet pipe **26** and waste gases leave through exhaust pipe **28**.

For heating the bulk material **11** in the basket **10** to the desired temperature for effecting gas plating, infrared radiators **30** are arranged about the plating chamber **10** and the infrared light waves focused upon the work load in the basket. Suitable reflectors **32** are positioned about the infrared radiators and arranged to concentrate the infrared rays onto the work to be gas plated. In the apparatus embodiment illustrated in FIGURES 1 and 2, a wire or woven metal basket **10** is utilized and which is rotated to tumble the objects about during gas plating. Infrared heat rays are directed primarily at the cylindrical sides of the basket which is rotated about a substantially horizontal axis.

In the modification shown in FIGURES 3, 4 and 5, in place of a wire basket there is employed a solid walled barrel or container **35** for holding the objects or articles to be gas plated. Such a container **35** is rotatably positioned within a chamber **36** which is transparent to infrared rays, the container **35** being suitably shaped of sheet metal and left open at one end as shown at **37**. Container **35** is keyed to a shaft **39**, the latter being adapted to be rotated similarly as shaft **12** to tumble the objects **40** about during gas plating. In the embodiment illustrated, the shaft **39** is disposed at an angle of approximately 30° to the horizontal. This angle is not critical and may be between 20° or 30° or thereabout, such that the work being plated will not fall out of the container or barrel **35** upon rotation of the same.

Infrared radiant heat lamps **42** are arranged forward of the open end of the barrel **35** and the heat rays directed into same through the open end and onto the objects **40** being gas plated. Suitable reflector means **44** are provided to redirect infrared rays into the open end of the barrel **35**. Plating gas is admitted to the chamber **36** through a conduit **46** and into the interior of the barrel **35** and in contact with the heated objects **40**. The gas plating apparatus illustrated in FIGURES 3 to 5 is suitable for gas plating bulk aggregates such as powders or finely divided solids which cannot be retained on a woven wire cloth basket. To assure continuous and uniform movement of the work being plated with resultant even exposure of the particles during gas plating, spiral-shaped baffles **49** are suitably positioned on the interior side wall surface of the plating barrel **35**. Such baffles are shaped and positioned on the side walls whereby upon rotation of the barrel **35**, and which is preferably keyed to the shaft **39**, the work or charge therein will move slowly from the front to the back.

To assure continued flow or even movement of the charge such as powdered material, a vibrator, not shown, may be suitably attached to the equipment, for example the bearing portion **50** carrying shaft **39**. The vibration is effective in reducing any tendency of the particles of the charge to stick together. For adjustably supporting the rotatable plating barrel **35** and enclosing chamber **36**, the same is mounted on a pair of leg members **52** and **53**. These leg members are in turn secured to the upstanding lugs **54** and **55** respectively, by a pivot bolt **57** and **58**. Angular adjustment of the plating equipment is obtained by pivoting the same about the pivot bolts **57** and **58** and locking the same in place by positioning a lock screw in one of the holes **60** of the lug member, as illustrated in FIGURE 3.

For adjustably supporting the infrared lamps **42** and associated reflector **44**, the same is suitably supported as at **61**, by the links **62** and **63** which are pivotably secured together and to the base **64** by winged nuts **65**, **66** and **67**. This construction permits the infrared lamps and reflector to be positioned directly adjacent the barrel opening **37** and so as to focus and concentrate the rays onto the work. Further, to cool or maintain the infrared transparent wall **70** at least below the temperature at which the plating gas thermally decomposes, air at controlled temperature is discharged against the wall **70** from a conduit **72**, as indicated by the arrows **74** in FIGURE 3.

Suitable glass or plastic material which is transparent to infrared heat rays forms the walls or windows of chamber **20** and chamber **36** enclosing the rotatable barrel or container in which the bulk articles to be metallized are placed. For this purpose borosilicate glass and clear fused quartz may be used. A wall thickness of 1/16 inch or less is applicable. Thin sheet plastic film may be used in place of glass. Plastic sheets made of polyethylene terephthalate resin, and such as sold commercially under the trade name Mylar is suitable. Similarly a clear plastic film of tetrafluoroethylene resin and commonly marketed under the trade name Teflon is useful. Other materials, of course, may be employed which are transparent to infrared rays and possess sufficient strength and heat stability.

In FIGURES 6 and 7 there is illustrated another embodiment for gas plating bulk material. A rotatable barrel or container **80** is provided for holding a bulk charge **82**, e.g., small screws, bolts and nuts, which is heated by the use of infrared heat radiators **83**. The infrared radiators **83** are suitably arranged in the rotatable barrel **80**, and within an infrared transparent vapor proof shield **85**. Wall **86** of the shield is made of material transparent to infrared rays. The shield **85** is kept cool, or heat-controlled to the desired low temperature, by a stream of air which is moved axially of the barrel through the interior of the shield as shown by the arrows **87**. To achieve this, the shield chamber **87** is connected with conduits **88** and **89** which extend outwardly through the barrel bearing mounting posts **91** and **92** respectively, as shown in FIGURE 6.

As illustrated in FIGURE 6, the work charge **82** is positioned in the barrel **80** which is suitably hermetically sealed against the surrounding atmosphere and the infrared radiator shield **85**. Access to the interior of the barrel **80** is provided by an opening **94** which is kept closed by a gasket equipped panel **95**, the latter being secured in place by winged nuts **96**. Plating gas is admitted to the barrel **80** and in contact with the work charge **82** by a conduit **98**, and waste gases are discharged through conduit **99**.

In FIGURES 8 and 9 is illustrated a further modified apparatus for gas plating bulk material which employs a vibrating channel as gas plating chamber. This modified structure provides an apparatus for gas plating metal on a moving work load exposed to infrared heat rays and vapors of a thermally decomposable metal compound. The gas plating channel in which the work charge is retained is made to vibrate approximately parallel to its longitudinal axis by rapid non-harmonic vibrations or mechanical movement. Such vibrations are of the type that move rapidly in one direction and relatively slowly in the reverse direction. This results in causing the mass of articles constituting the charge to move from hopper to exit and tumble about whereby the entire surface of each article is exposed and contacted by the metal plating gas.

Referring to the modified apparatus in FIGURES 8 and 9, as shown, a vibratable gas plating chamber **102** is provided having an inlet **104** and outlet **105**. A hopper **107** for feeding bulk material **109** to be metallized is connected to the inlet **104**. For heating the bulk material **109** during gas plating, infrared radiators **112** and associated reflector means **113** are arranged over the plating chamber **102**, as illustrated in FIGURES 8 and 9. Contiguous with the top wall **114** of the plating chamber **102** is a cooling air duct through which air is blown or moved by suction to control the temperature of the walls through which the infrared heat passes. The walls of the cooling air duct as well as the wall **114** are made of infrared transparent material.

Plating gas is adapted to be admitted through a conduit **116** adjacent to the inlet **104** of the plating chamber, and waste gases are discharged through an exhaust conduit **118** connected to the outlet **105**.

To provide for vibration of the gas plating chamber **102** there is suitably connected to the bottom wall **100** of the chamber a channel member **122** which in turn is mechanically connected to a non-harmonic vibration source as at **123**, whereby the plating chamber **102** is vibrated during the gas plating operation. Suitable baffles **125** are disposed lengthwise of the bottom wall **120** or floor of the plating chamber, as illustrated in FIGURE 8, to obtain recirculation of the work charge. This brings about even and uniform gas plating of metal onto the entire surface of articles making up the charge.

In carrying out my process, where it is difficult to obtain a tenaciously adherent metal deposit, and such as occurs with the gas plating of certain metals, the work charge is subjected to a preheat treatment. Such treatment consists in heating the charge to a temperature substantially above the gas plating temperature, for example 600° to 800° F. in the presence of hydrogen. After this preliminary treatment, the gas plating is carried out at a lower temperature and at the temperature which causes heat decomposition of the gaseous plating metal compound with deposition of metal. Where the residual heat of the charge after preheat treatment is sufficient to accomplish the decomposition of the plating gas, the infrared radiators may be cut off during gas plating.

The preferred sequence of operations for gas plating metal to metallize articles in bulk, as described, and employing the apparatus illustrated and described, is as follows.

The gas plating barrel, basket or container is charged with the bulk material or numerous articles or particles to be metallized. The barrel or container is then closed and air is purged therefrom by an inert or unreactive gas, e.g., helium, argon, carbon dioxide, with or without small amounts of hydrogen. After removal of air from the plating container, the infrared radiators or heat source is actuated and the rays directed into the barrel or container and focused on the bulk material constituting the work charge. The barrel is then continuously rotated or oscillated to cause the work charge to be uniformly tumbled about while vapors of the heat decomposable metal compound are introduced into the barrel and in contact with the heated charge.

After a predetermined interval of time, depending upon the desired thickness of the plating metal deposit, the flow of plating gas vapors is terminated and the heat shut off. The barrel is again purged of gases by the introduction of inert gases, after which the plating barrel is opened and the metallized work charge removed.

While in the apparatus illustrated and described reference is made to a rotatable or oscillatable barrel or container for holding the work charge, it will be understood that such rotation need not be in only one direction, but one direction and then another. For example, the barrel or container may be rotated rapidly, say one degree in one direction, then slowly rotated one degree in the opposite direction or similarly oscillated about its longitudinal axis by a non-harmonic motion. The movement in each case being such as to bring about uniform and continuous revolution of the bulk charge while thus heated and heat decomposable plating gas circulated in contact therewith. In like manner, by employing an apparatus such as illustrated and described in FIGURE 8, the work

load or charge may be caused to move therealong through a channel chamber while subjected to a rapid longitudinal non-harmonic vibration while infrared heat is directed onto the work load through infrared transparent walls or windows of the barrel and/or surrounding chamber.

It will be understood by those skilled in the art that variations of the apparatus and embodiments herein illustrated and described may be made without departing from the spirit and scope of my invention. Such modification as may be required to adapt the invention to different conditions and uses are contemplated to come within the purview of my invention, and as set forth in more particularity in the appended claim.

What is claimed is:

Apparatus for metallizing articles in bulk form and comprising a cylindrical container of wire mesh for holding the articles to be metallized, means for mounting said container for rotation about its longitudinal axis, a cylindrical casing enclosing said container and defining a chamber; means comprising infra-red heat radiators arranged about and within the periphery of said casing for heating said articles; radially spaced cylindrical infra-red transparent walls positioned between said container and said infra-red heat radiators to provide annular cooling air space and means for circulating cooling air through said space, means for rotating said container to cause said articles to tumble about therein, said heating means being controlled to heat said articles to a temperature to cause thermal decomposition of vapors of a heat-decomposable metal compound brought in contact therewith, and means comprising conduits connected to said chamber inside of the transparent walls through which said vapors of a heat-decomposable metal compound are introduced into said chamber and in contact with said articles.

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