

[54] APPARATUS FOR PLATING HEAT-RESISTANT ARTICLES

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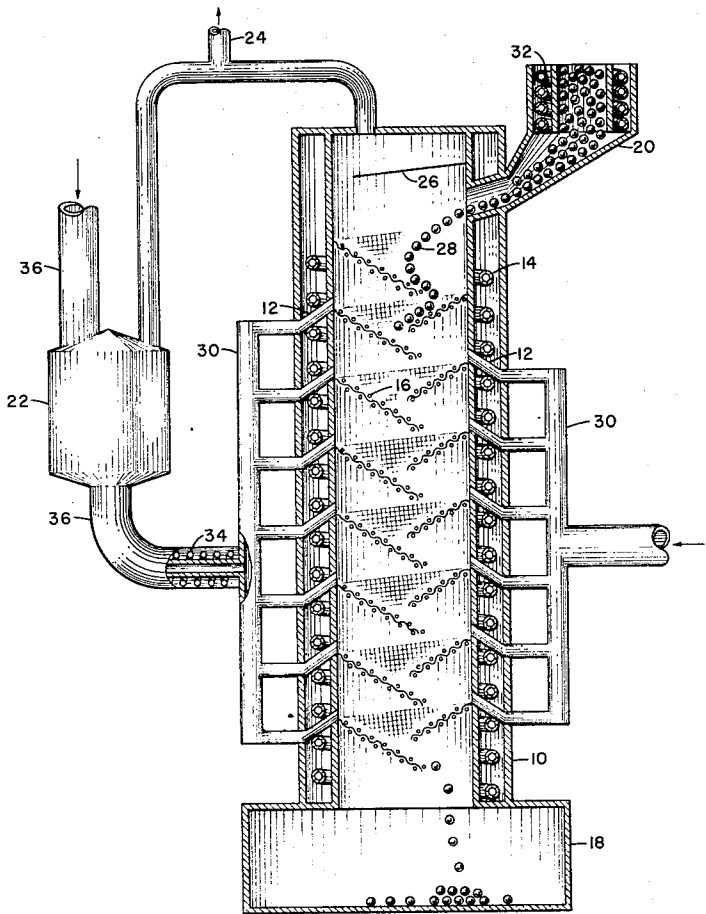
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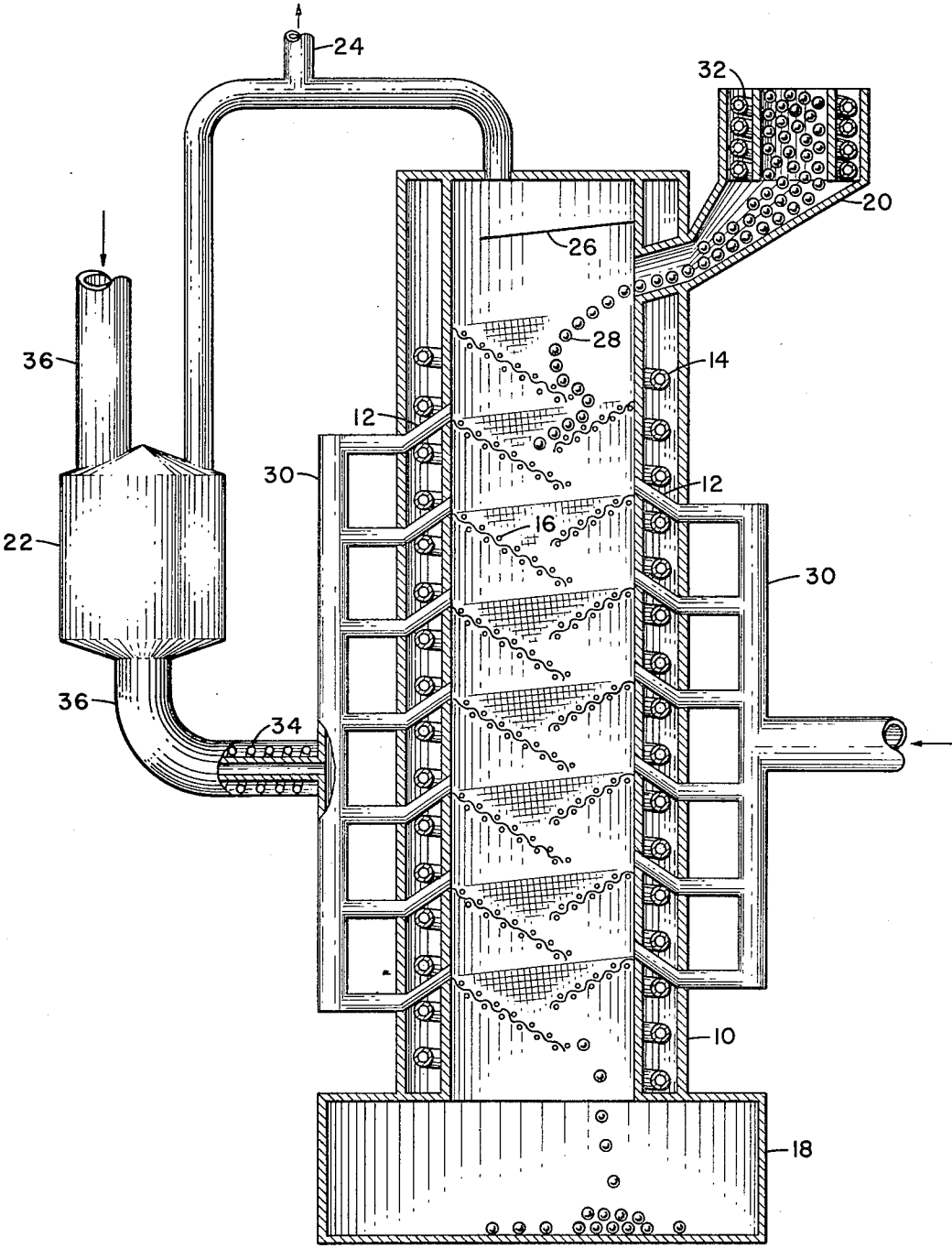
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[57] ABSTRACT

Apparatus for plating heat-resistant articles which includes a hollow reaction chamber having a plurality of wire trays so positioned in the reaction chamber to control the fall of the articles through the chamber, a plurality of spray nozzles so positioned in the walls of the chamber to disperse plating solution throughout the reaction chamber, means for heating the reaction chamber located along the walls thereof, a supply of plating solution connected to the spray nozzles to transfer the solution to the reaction chamber for the plating of the falling articles in the chamber, and a means for continuously recovering the plated articles.

6 Claims, 1 Drawing Figure





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APPARATUS FOR PLATING HEAT-RESISTANT ARTICLES

This invention relates to an apparatus for plating of heat-resistant articles and more particularly to apparatus for plating a metal on the surface of a heat-resistant article by passing the article while hot into contact with an atomized spray of the plating solution which contains a compound of such metal.

Plating of various substrates with protective metallic coatings such as zinc, aluminum and tin is a widely used industrial process. In the majority of the prior art techniques, the substrate to be plated is alternately heated and immersed in a plating solution such as an aluminum alkyl solution in a cyclic fashion until the desired thickness of coating is obtained. This cyclic type of technique requires an undue length of time and if the partially coated substrate is not maintained in an inert atmosphere between the immersion steps an oxide layer tends to form on the previously deposited aluminum which is detrimental to the completed coating. Prior to the present invention no apparatus has been provided to produce a desired thickness of coating in a single pass of a substrate through an atomized plating solution. Prior art units employing the vapor phase principle have been plagued with the problems of high material cost, lack of efficiency, and relatively slow rate of deposition.

The present invention provides an apparatus for plating a heat-resistant substrate by the contact thereof with a plating solution in the form of a mist. Though not limited to such usage, the apparatus is particularly useful in aluminum plating metallic objects such as nuts, bolts, metal fasteners, etc. by contacting the substrates while hot with a plating solution in the form of a mist containing an alkyl aluminum compound.

Broadly described, the apparatus of the present invention comprises a hollow reaction chamber having means for introducing substrates to be plated in the upper portion thereof; heating means positioned along the walls of the reaction chamber; a plurality of spray nozzles dispersed throughout the walls of and facing into the chambers; a plating solution container communicating with the spray nozzles for the transfer of the plating solution to the reaction chamber; and means for tumbling the substrates to be plated while gravitating through the reaction chamber and a means for recovering the plated substrates. For the purposes of the present invention, the reaction chamber should at least be longer than it is wide and preferably at least twice as long as it is wide for the plating of articles of irregular shape having dimensions of from about 0.16 inch to about 1.0 inch.

In a preferred embodiment the apparatus includes in the reaction chamber a plurality of vertically spaced aligned wire trays each of which has a downward directed slope. Induction heating coils are positioned along the walls of the reaction chamber so that the substrates to be plated falling therethrough are heated to the requisite temperatures to achieve quality plating. Means is provided for feeding plating solution to the spray nozzles so as to coat therewith to produce a mist of plating solution in the reaction chamber. Also, means is provided for feeding various articles to be plated into the upper portion of the reaction chamber so that upon moving through the reaction chamber and

among the wire trays the substrates are contacted with the mist of plating solution and are plated thereby and collected in the bottom of the reaction chamber by means provided therefor.

Various means for recovering the plated articles can be employed in the present apparatus; for example, a collection bin at the bottom of the chamber as shown in the FIGURE, and as an alternative thereto, the plated articles can be directed to a kerosene rinse bin through an opening near the bottom of the chamber for temporary storage and further a container at the bottom of the chamber could then be utilized to receive excess plating solution which can be recycled for use in the plating of falling articles.

The use of the kerosene rinse bin for the collection of the plated articles enables the articles to be continuously removed from the apparatus without disturbing the operation thereof to achieve a continuously operating process in said apparatus.

Also, in order to aid in the quality plating of the articles, it would be suitable to employ a vibrating means attached to the means for tumbling the articles through the chamber. The vibrating of the tumbling means would provide adequate means for preventing the clogging of the apparatus by the falling articles.

An object of the present invention is to provide an improved apparatus for plating various substrates. A more specific object of the invention is to provide an apparatus for continuously plating a hot substrate by contacting it with a plating solution in the form of a mist.

An additional object of the invention is to provide an apparatus for continuously aluminum plating a metallic substrate.

A further object of the invention is to provide an improved apparatus for enhancing the rate at which a high quality aluminum coating can be formed on a metallic substrate.

Another object of the invention is to provide an improved apparatus for the plating of various articles having irregular geometric configurations.

Additional objects and advantages will become apparent as the following detailed description of the invention is read in conjunction with the accompanying drawing which illustrates the invention.

The sole FIGURE of the drawing is a view partially in elevation and partially in section of one embodiment of the apparatus of the invention.

In one form, as illustrated in the drawing, the apparatus of the invention includes a hollow vertical reaction chamber 10. Dispersed throughout the reaction chamber 10 are a plurality of vertically spaced aligned wire trays 16, each of which is so positioned to have a downward slope so that articles to be plated introduced through feeder means 20 are tumbled through the reaction chamber 10. A supply 22 of plating solution is connected to conduits 30 for the transfer of plating solution to a plurality of spray nozzles 12 which are spaced vertically and aligned in the walls of reaction chamber 10 to provide a mist of plating solution throughout the entire length of the reaction chamber 10. At the lower portion of reaction chamber 10 there is provided a collection bin 18 for the receipt of articles 28 upon being plated.

Positioned along the walls of reaction chamber 10 there is an induction heating coil generally designated as 14. In the upper portion of reaction chamber 10 there can be provided a disengaging plate 26 so positioned to prevent the exit of plating solution along with inert gases 36 as they pass through outlet 24 for flaring.

In the practical application of the present invention to produce quality plating, heating means designated as 32 and 34 should be provided to heat the articles to be plated and the plating solution respectively.

Articles 28 which are to be plated with the illustrated apparatus upon heating by means 32 are introduced into reaction chamber 10 through feeder means 20. Upon entering the reaction chamber 10 articles 28 fall among wire trays 16 which cause articles 28 to tumble, thereby exposing the surfaces of articles 28 to the mist of plating solution being sprayed into reaction chamber 10 through spray nozzles 12 which are being supplied with plating solution from container 22 after passing through heating means 34. While articles 28 are falling therethrough, reaction chamber 10 is being kept at the requisite plating temperature by heating coils 14. After being plated during their fall through reaction chamber 10 articles 28 are collected in collection bin 18.

It should be noted to assure efficient utilization of the organo-metallic chemical on articles 28, means should be provided to accomplish an upward draft of the plating mist entering the chamber. Various means can be used to provide this upward draft. For example, the collection bin can be kept at temperatures above that in reaction chamber 10 or a stream of an inert gas can be introduced at the bottom of reaction chamber 10 in the operation.

Since one of the most useful applications of the apparatus of the invention is for aluminum plating of metal substrates, the use of the apparatus illustrated in the drawing will be further described with reference being made to the employment of the apparatus for this purpose. It is to be understood, however, that plating of other materials on substrates of various types can be carried out with the depicted invention and that the following description is intended to be illustrative of but one possible usage of the apparatus.

In the plating of aluminum on metallic substrates with a plating solution containing a thermally decomposable alkyl aluminum solution it is essential that careful temperature control of the metallic substrate in contact with the plating solution be maintained. The mechanics of the plating process involves the thermal decomposition of the alkyl aluminum compound to deposit metallic aluminum on the surface of the metallic substrate. The temperature at which such decomposition will occur varies with the type of alkyl aluminum compound in use. In general, however, the article to be plated is heated to a sufficiently high temperature so as to cause decomposition of the aluminum alkyl compound upon contact with its surface. The apparatus of the present invention is so designed to utilize nearly all the heat stored in the article to decompose the aluminum alkyl compound in contact with its surface with minimum heat loss to the environment. Therefore, the temperature of the article to be plated can provide a means of controlling the thickness of the film deposited on its surface. The plating temperature, however, should not exceed about 500°C. and

preferably, below 480°C. in order to prevent the formation of harmful alloys, intermetallic layers, aluminum carbide, carbon and other extraneous deposits which can be harmful to the quality of the coating.

The alkyl aluminum compound contained in the plating solution has the formula $AlR(R')_2$, where R is an alkyl radical containing from one to 30 carbon atoms and R' is selected from the group consisting of alkyl radicals containing from one to 30 carbon atoms and hydrogen. Aluminum diethyl hydride is the preferred compound used in this type of plating because of its relatively low decomposition temperature which in turn results in lower heat energy requirements for the operation of the apparatus. The aluminum alkyl compound can be dissolved in a solvent which may typically be an inert petroleum distillate and which has a boiling point above the decomposition temperature of the particular alkyl aluminum compound in use. It should be pointed out, however, that a plating solution of pure alkyl aluminum compound may be used effectively. Typically, a solution which contains 50 weight percent aluminum diethyl hydride and kerosene is employed in the process.

Those skilled in the technology of alkyl aluminum chemistry will appreciate that the compounds of this type are pyrophoric materials requiring adequate safety precautions in their handling to prevent fire and explosion. Accordingly, the apparatus depicted in the drawing is preferably provided with suitable environment or ancillary equipment for blanketing the alkyl aluminum mist in reaction chamber 10 with an inert atmosphere. Therefore, along with their use as a propellant, inert gases can be used in order to provide a safe operation. The inert gases as propellants, serve a mechanical function of aiding in the atomization of the plating solution, such function can also be performed by other mechanical means.

In the utilization of the apparatus of the invention for plating metallic substrates such as nuts, bolts, metal fasteners, etc. with aluminum using aluminum diethyl hydride as a source thereof, such articles to be plated are first cleaned thoroughly using techniques and materials well known in the art and then heated by means 32 in feeder 20, in the absence of oxygen and preferably in the presence of hydrogen and other inert gases to a temperature of about 550°F. to about 800°F. prior to introduction into the plating chamber 10. Before introduction of articles 28 into reaction chamber 10, chamber 10 must be thoroughly purged of any oxygen or other oxygen-containing compounds or any other materials that might be injurious to the material and the process involved. Articles 28 introduced into reaction chamber 10 by feeder 20 are allowed to descend through reaction chamber 10 among wire trays 16 which provide a measure of control of articles 28 residence time in the chamber and to effect tumbling of the articles in order to insure complete and uniform exposure of the entire surface of the article being plated to the mist of heated plating solution being introduced into reaction chamber 10 at a temperature of about 300°F. to about 350°F. through spray nozzles 12 which receive said plating solution through conduits 30 from solution container 22. The plating solution is heated by means 34 provided therefor prior to its transfer through conduits 30 to spray nozzles 12. Articles 28 upon being

plated in their descent through reaction chamber 10 are received and collected in means 18 provided therefor. It should be noted that while in the illustration of the apparatus the use of nitrogen and hydrogen as propellant gases is indicated, other gases which are inert to the process may be utilized or substituted for the indicated gases. For example, nitrogen, helium, argon or similar inert gases are satisfactory for the process. An outlet means 24 is indicated in the illustration for the flaring of such propellant gases. Disengaging plate 26 as indicated in the upper portion of reaction chamber 10 is provided for the prevention of plating mist from passing out of outlet 24 along with the propellant gases. Various methods can be used for this purpose and with modifications thereof. While articles 28 are descending among wire trays 16 in reaction chamber 10 heated by means 14, the aluminum diethyl hydride plating solution is being sprayed into the chamber by spray nozzles 12 to form a mist therein. The aluminum diethyl hydride decomposes on the hot surface of the articles 28 resulting in lustrous, continuous, dense and inherent aluminum film.

Although a preferred embodiment of the invention has been illustrated in the drawing and described herein, in order to provide an example of the practice of the invention, it is to be understood that various changes and innovations can be made in the described apparatus without departing from the spirit and scope of the invention. Innovations and changes of this type are deemed to be encompassed within the spirit and scope of the invention.

The present invention provides means for the practice of liquid phase deposition which yields superior plating as compared to prior techniques of vapor phase deposition with the elimination of many problems encountered by the dipping or immersion technique of liquid phase deposition. Control of the variables effecting quality and thickness of film can be accomplished easily and accurately with the present invention. The present invention is particularly advantageous in the plating of articles of irregular geometric configurations having dimensions of between about 0.16 inch to about 1.0 inch with uniform and control thickness ranging between 0.03-5 mils or thicker in a single pass or exposure to the plating solution. Although this invention has been disclosed and described in relation to aluminum

films, it can also be applied to other metals as well as other heat-resistant substrates. Further, the present invention is applicable to gas phase deposition as well as liquid phase deposition as disclosed and described herein.

What is claimed is:

1. Apparatus for plating heat-resistant substrates with an atomized plating solution comprising:
 - a hollow reaction chamber having a means for introducing said substrates in the upper portion thereof;
 - heating means positioned along the walls of said chamber;
 - a plurality of spray nozzles dispersed in the walls of and facing into said chamber;
 - a plating solution container communicating with said spray nozzles for the transfer of said plating solution into said reaction chamber;
 - a means for tumbling said substrates while gravitating through said reaction chamber for plating thereof; and
 - a means for recovering said plates substrates from the lower portion of said reaction chamber.
2. Apparatus for plating substrates as defined in claim 1 wherein said means for tumbling said substrates comprises:
 - a plurality of wire trays so positioned in said reaction chamber to slow the fall of and tumble said substrates therethrough.
3. Apparatus for plating substrates as defined in claim 1 wherein said heating means comprises:
 - an induction heating coil positioned to surround said reaction chamber.
4. Apparatus for plating substrates as defined in claim 1 wherein said recovery means comprises:
 - a collection bin positioned at the lower portion of said reaction chamber to collect the plated substrates.
5. Apparatus for plating substrates as defined in claim 1 wherein said heat-resistant substrates are of irregular geometric configurations.
6. Apparatus for plating substrates as defined in claim 1 wherein said means for introducing said substrates comprises:
 - a feeder bin having a means for heating.

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