



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

OCT 15 1973

TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,754,976

Government or Corporate Employee : Government

Supplementary Corporate Source (if applicable) : _____

NASA Patent Case No. : GSC-11,163-1

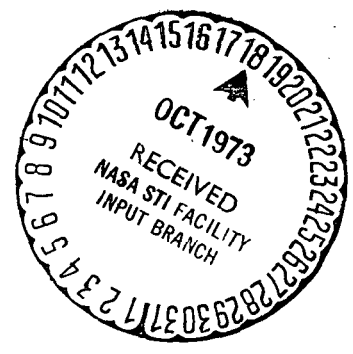
NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes No

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

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Enclosure
Copy of Patent cited above



[54] PEEN PLATING

3,025,182 3/1962 Schrewelius 117/105.5 X
3,020,182 2/1962 Daniels 117/105.5 X

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[73] Assignee: The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, Washington, D.C.

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[22] Filed: Dec. 6, 1971

[21] Appl. No.: 205,047

[57] ABSTRACT

[52] U.S. Cl. 117/105, 29/527.2, 72/53, 117/66, 117/105.5, 117/130 R, 117/138.8 R, 117/151, 117/160 R

[51] Int. Cl. B44d 1/02

[58] Field of Search 117/104 B, 105, 105.5, 117/50, 66, 130 R, 151, 160 R, 138.8 R; 29/527.2; 72/53

A process for metal plating which comprises spraying a mixture of metallic powder and small peening particles at high velocity against a surface, said velocity being sufficient to impact and bond said metallic powder onto said surface.

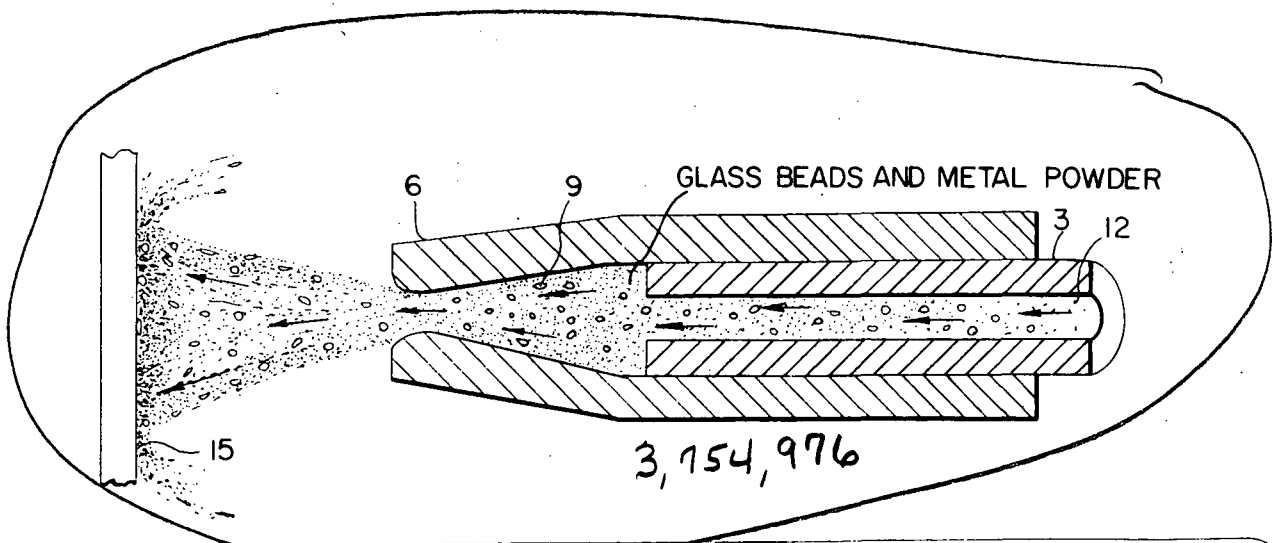
In the case of metal surfaces, the process has as one of its advantages providing mechanical working (hardening) of the surface simultaneously with the metal plating.

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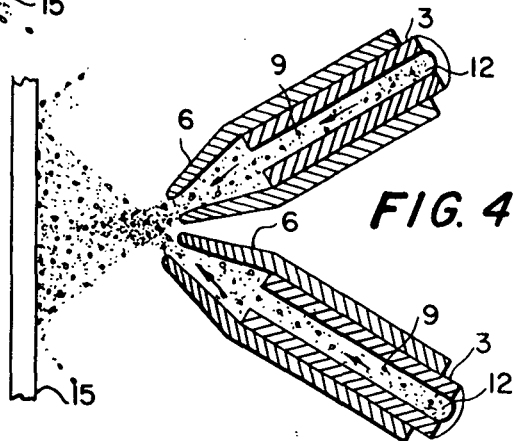
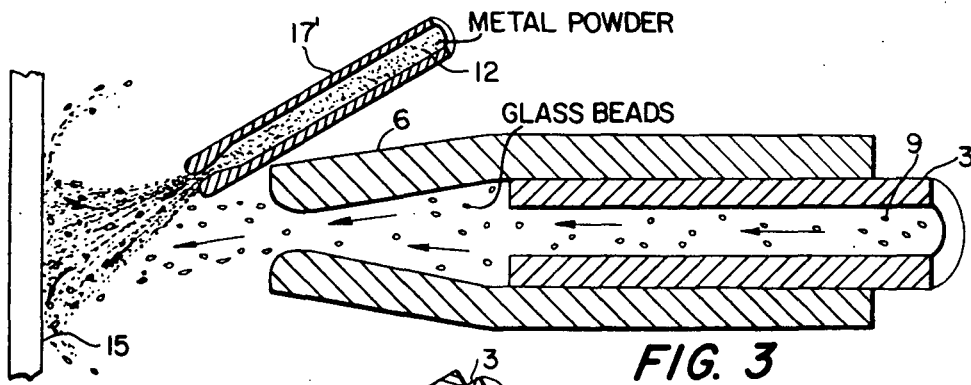
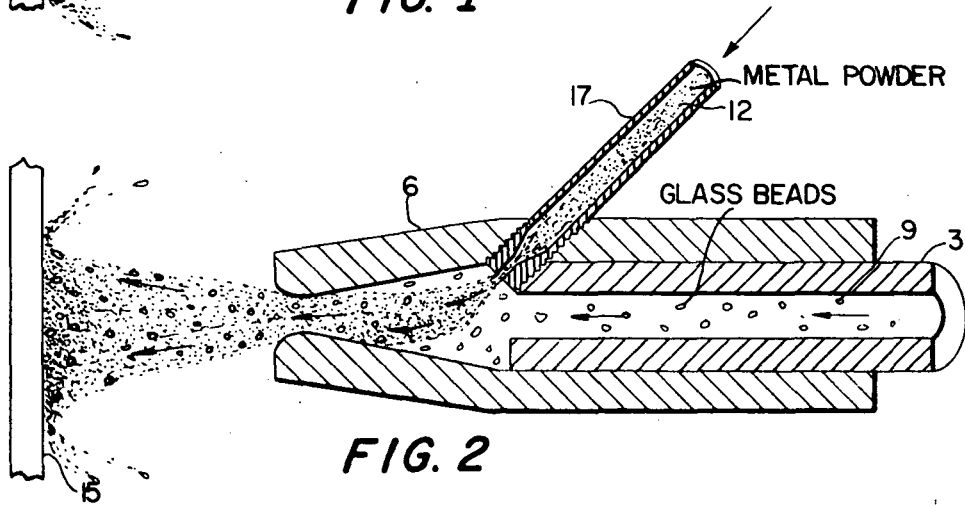
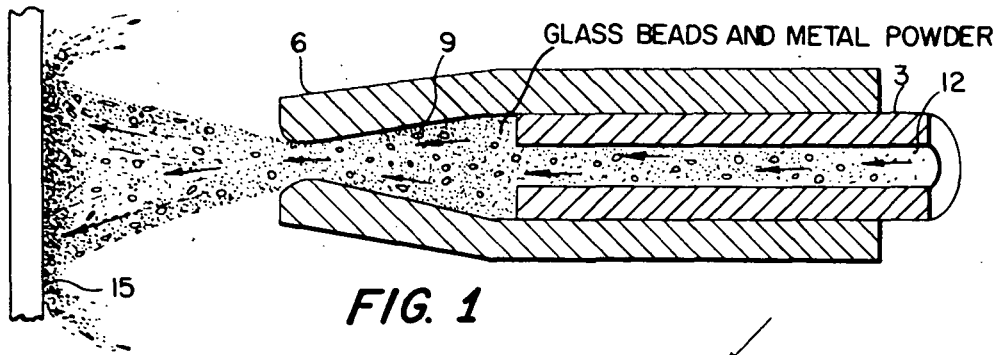
10 Claims, 4 Drawing Figures



(NASA-Case-GSC-11163-1) : PEEN PLATING
Patent (NASA) 6 p CSCL 13H

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PEEN PLATING

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government 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

Field of the Invention

This invention relates to the metal plating of substrates such as metal substrates. More particularly, the present invention is directed to the deposition of metallic coatings on other substrates by peening metallic powder onto the surface of the substrates.

Description of the Prior Art

Numerous methods are known in the art for the metallic plating or coating of substrates. Among these methods can be mentioned application of metallic coatings by electro chemical and chemical deposition in tanks of aqueous solutions of metal salts, by immersion into molten baths of the metal and by spray and brush application as a paint.

Although these prior art techniques have enjoyed some commercial success they are not without their shortcomings. Many of the prior art techniques, for instance, involve the use of hazardous chemicals and/or fumes. Others are characterized by less than desirable deposition rates and a tendency to cause hydrogen embrittlement. Most of the prior art methods, moreover, are limited in the number of substrates they are capable of coating. Another common complaint heard against certain prior art techniques is the complexity and costliness of the equipment required. Lastly, all of the aforementioned prior techniques do not effect any mechanical working (hardening) of the substrate surface and, therefore, do not benefit from such working.

One object of the invention is to provide a method for metal plating surfaces which does not involve hazardous chemicals and/or fumes and which precludes the possibility of hydrogen embrittlement.

Another object of the invention is to provide a process which plates at a more rapid rate than prior art methods and does not require complex or costly equipment to operate.

Yet another object of the invention is to provide a process for the deposition of a metallic coating which simultaneously effects a desirable mechanical working (hardening) of the substrate surface.

A further object of the invention is to provide a process for the metallic coating of substrates wherein the substrate surface is conveniently preconditioned before the metallic coating is applied.

These and other objects of the invention will become apparent or will be pointed out with particularity as the description proceeds.

BRIEF SUMMARY OF THE INVENTION

In accordance with the process of the invention the surface of a substrate is metal plated by spraying the surface with a mixture of metallic powder and small peening particles at a high velocity sufficient to impact and bond the metallic powder onto the surface.

Another aspect of the invention involves first preconditioning the surface of the substrate by effecting the

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spraying without the metallic powder and then subsequently introducing the metallic powder into the stream of small peening particles to form the admixture sprayed at peening velocity against the surface to be plated.

Still another aspect of the invention involves plating the substrates with two or more metal powders fed simultaneously or alternately into the stream of peening particles or with metal and non-metal powders similarly applied, to effect mixtures or layers onto the substrate surface.

Without being bound by any theory or scientific explanation of how precisely the present invention effects the uniform metal plating, it is believed that, for the most part, the following sequence of events occurs in rapid succession many times through the spraying operation: 1) the peening particles create a multitude of depressions or peened cavities in the substrate surface which depressions may be said to resemble "oceanic waves" 2) metallic powder from the spray stream settles in the depressions or peened cavities and is pounded in by the next or ensuing peening particle or particles. In the case of metal surfaces, the peening of the surface that occurs prior to and simultaneously with the metal plating or coating constitutes a mechanical working (hardening) of the substrate surfaces which improves the substrate, for instance, by 1) hardening the surface, 2) introducing compressive residual stresses for fatigue improvement, 3) eliminates tool marks, etc.

DETAILED DESCRIPTION OF THE INVENTION

The means for spraying the mixture of metallic powder and peening particles may comprise, for instance, any suitable air or other gas pressured equipment that is capable of propelling powder and peening particles as a spray stream at a peening velocity. Essentially the same techniques as are involved in sand blasting are applicable to the spray step of the invention. Alternately, airless means for the propulsion of peening media can be used. This airless method of peening media propulsion incorporates a rotating wheel with hoppers located around its perimeter. The speed of rotation of the wheel determines the intensity with which the media strikes the part being processed. Thus, with regard to the means for spraying the mixture of metallic powder and peening particles, the only essential consideration is that the equipment be capable of spraying out the small particles at peening velocity. By "peening velocity" is meant a velocity sufficient to cause the substrate surface to be cleaned and to effect minute depressions in the surface and to cause bonding of the metallic powder to the surface. Hence, the design of the nozzles used to direct the stream of metallic powder and peening particles can vary considerably as shown in the attached drawing wherein:

FIG. 1 is a sectional view of a spray nozzle useful in the process of the invention whose design is such that the mixture of metallic powder and peening particles pass through its entire length;

FIG. 2 is a sectional view of another type of spray nozzle means comprising a primary nozzle through which the peening particles are passed and a separate secondary nozzle by which the metallic powder is introduced;

FIG. 3 is yet another type of spray nozzle means which may be used in the process of the invention com-

prising a primary nozzle through which the peening particles are introduced and a separate secondary nozzle arranged to direct metallic powder into the stream of peening particles outside the primary nozzle; and

FIG. 4 represents the embodiment of the invention wherein a plurality of the spray nozzle means of FIG. 1 are employed.

Referring to FIG. 1, a conduit 3 is attached to a source of compressed air (not shown) to provide a blast of air that propels the mixture of metal powder and particles. A spray nozzle 6 is fitted onto conduit 3 for directing the air spray. A supply of small spherical particles such as glass beads 9 and metallic powder 12 are admixed in a hopper (not shown) and both propelled first through conduit 3 and then nozzle 6, exiting as a spray stream which impinges upon a substrate 15.

Directing attention to FIG. 2, the design of the spray nozzle means depicted therein is identical to that of FIG. 1 except that a secondary spray nozzle 17 is threadedly engaged to spray nozzle 6 for the separate introduction of metal powder within the nozzle head of spray nozzle 6 which separately introduces the small glass beads.

The spray nozzle means of FIG. 3 is identical in design to that of FIG. 1 except that a separate external secondary spray nozzle 17' is arranged to introduce the metallic powder directly into the spray stream of the peening particles emanating from spray nozzle 6.

In FIG. 4 a plurality of the spray nozzle means of FIG. 1, each comprised of a conduit 3 attached to a source of compressed air and a nozzle 6, are inwardly directed to spray the mixture against the substrate 15.

It also should be understood that the size of the nozzle apertures can be varied. Additionally, one nozzle with two or more ports and separate valving can be used with separate air pressures to direct the various streams to form one in front of the nozzle, or two or more individual nozzles can be employed to obtain the same effect.

Although the preferred small peening particles of the invention are spherical peening particles such as glass beads, other suitable peening particles include metal shot, ceramic beads and the like. Further, the peening particles need not necessarily be spherical in shape and can take the form as generally commercially available. The sizes of the peening particles that may be used in the process can be those of the conventional beads used for peening and blast cleaning. Ordinarily, the peening particles range in size from about 0.0661 inch in diameter to about 0.0010 inch in diameter. However, for large and thick substrates, even larger beads to about 0.1000 inch diameter may be used with properly sized equipment.

Any metallic powder of varying degrees of hardness and particle shape, (for instance, flake or spherical) is contemplated for use as the coating material in the present invention. Illustrative of metallic powders that may be used are aluminum, nickel, silver, gold, tungsten, copper, zinc, etc. In general, the size of commercially available metallic powders will range from about -100 mesh to +270 mesh, any one of which is suitable for use in the process of the invention. The metallic powder size selected, however, should be no larger than about one half the peening particle size for good coating. The precise size of metallic powder employed will depend in large part upon practical considerations such as the speed of the process and the thickness of

coating desired. Should, for example, a thin layer of plated metal be desired, a size ratio of metal powder to peening particle down to about 1:20 can be employed.

A unique feature of the invention is that two or more different metallic powders can be introduced into the peening particle stream simultaneously or alternately; or metal and non-metal powders can be applied together or in layers. This feature has been found to offer a number of practical uses and advantages. For instance, one stream could be a soft metal powder to provide electrical or thermal conduction and the other stream could be a hard metal powder to provide wear resistance.

The proportions of peening particles to metallic powder employed in the process may vary widely, the proportions selected depending primarily upon the substrate, the pressure used and the degree of peening or coating desired. If, for instance, it is desired to minimize peening and maximize plating a ratio of metallic powder to peening particles of about 50:50 can be employed. Although ratios of powder to peening particles in excess of 50:50 are employable they generally are unnecessary and frequently constitute a waste of metallic powder. On the other hand, if it is desired to maximize peening and minimize plating ratios of metallic powder to peening particles less than 50:50, down to, for example, 10:90 may be selected.

As aforementioned, the air or other gas pressure employed in the spraying of the metallic powder and peening particles is that sufficient to maintain free continuous flow and produce a peening effect at the distance the spray nozzle is held from the substrate or workpiece. The particular pressure employed in a given operation depends on several factors such as the hardness of the substrate, the distance the spray nozzle is held from the piece, the size and proportions of the metallic powder and peening particles and whether peening or plating is to be favored. Also, the pressure may be varied during the course of the operation. For instance, it may be desired to operate initially at a high pressure to clean the surface or to produce an intensity that hardens and introduces compressive residual stresses into the substrate, eliminates tool marks, etc., and then reducing the intensity by lowering the pressure to complete the plating operation.

The force intensity of the peening media (metallic powder and peening particles) can be varied by the air (or gas) pressure, the distance of the part from the nozzle, the rate of flow of the peening plating media into the air stream, the orifice size of the nozzle or any combination of these variables.

The substrates which can be metal plated or coated in accordance with the present invention include any hard material having a peenable surface. Such materials include metals and alloys, such as copper, steel, magnesium, aluminum alloys, etc., wood, plastics such as nylon, polyethylene, polypropylene, polymethacrylates, etc., fiberglass, ceramics, and the like.

In the embodiment of the invention wherein the surface of the substrate or workpiece is preconditioned by first effecting the spraying with the peening particles alone before introduction of the metallic powder into the stream, the preconditioning may take different forms. One form can comprise a surface cleaning operation whereby the part to be coated is cleaned with a gentle or low angle stream of peening particles to remove rust, scale, paint, etc., before introduction of the

metallic powder into the stream, thereby improving adhesion of the coating. Another form, in the case of a metal surface involves peening with a high-angle stream of peening particles to induce compressive stresses for fatigue and stress corrosion resistance, again before the flow of metal powder is begun. Yet another form, also in the use of metal surfaces, comprises a combination of the surface cleaning step followed by the peening step before the metal powder is cut into the stream.

The plating process is preferably conducted in a suitable cabinet or work chamber. The spray of peening particles and metallic powder is then simply directed at the desired areas of the workpiece. Areas not to be covered can be masked off with various pressure sensitive tapes or rubber or plastic coatings that can be removed easily at a later time. The longer the application time for a given set of conditions the thicker will be the resulting coating. If desired, standard means such as Almen strips as adopted by the Society of Automotive Engineers may be used for gauging and monitoring the intensity of the peening. Recommended Almen strip arc heights range from 0.002N to 0.012C depending on the thickness and type of material being plated, with the lower values being used for thinner and/or soft substrates and the higher values for thicker and/or harder substrates. Upon completion of the plating operation, the peening particles used may be discarded or reclaimed, as desired. Any unused metallic powder may also be recovered.

In practice, several nozzles could be employed, particularly in automatic or sequential operations. A part could move automatically into the spray paths of the several nozzles so prepositioned that all or portions of the part being processed contacts the sprays in the order of the desired plating with the nozzles spraying out peening media consisting of small beads and powders so selected to produce a variety of desired surfaces. The placement of nozzles could be arranged to produce layering of different plating materials. Additionally, the nozzles could be individually set to produce different peening intensities with different peening media. If pre-cleaning is required, the first set of nozzles would spray only the beads, without a powder, prior to any plating being accomplished.

The following examples are included to further describe the invention.

EXAMPLE I

In this example the plating process was conducted in a glass bead peening machine comprising an enclosed working cabinet containing a hopper and spray equipment including the nozzle depicted in FIG. 1 of the drawing. The nozzle used had an opening diameter of $\frac{1}{4}$ inch. An aluminum-magnesium alloy plate was placed in the machine 6-8 inches away from the nozzle. In the hopper equal proportions of .0041 to .0021 inch diameter glass beads and -100 mesh aluminum powder was mixed and the admixture spray "blasted" under an air pressure of 40-60 psig onto the surface of the aluminum-magnesium alloy plate. The total "blast" time for plating, for example, a 1 x 3 inch aluminum-magnesium alloy plate, was one-half minute. A mechanically worked substrate having a uniform coating of aluminum of one to two mils thickness thereon was obtained. Photomicrographs of the coated surface cross section at magnifications of 100X, and 250X clearly showed the peened nature of the interface inter-

locking achieved. The resulting aluminum-coated aluminum-magnesium alloy plate upon testing exhibited increased hardness and compressive residual stresses.

EXAMPLE II

The procedure of Example I was repeated substituting a steel substrate for the aluminum-magnesium alloy. An aluminum-plated steel substrate exhibiting similar characteristics was obtained.

EXAMPLE III

The procedure of Example I was repeated substituting a copper plate for the aluminum-magnesium alloy plate. An aluminum-coated copper plate exhibiting similar characteristics was obtained.

EXAMPLE IV

Example I was repeated but with the spray blasting for five minutes. A substrate having a substantially thick coating of about five mils of aluminum, but exhibiting the same desirable characteristics, was obtained.

EXAMPLE V

In this example the same equipment and materials employed in Example I were used except that the nozzle of FIG. 2 was substituted for the nozzle of FIG. 1 and a separate hopper was provided for the aluminum powder. The glass beads were first spray "blasted" against the steel substrate under a pressure of 60-80 psig in the absence of the aluminum powder to precondition the substrate surface. After one minute of this conditioning, the aluminum powder was pressured into the stream of glass beads at the same rate and the plating phase conducted for a period of one-half minute. Results similar to that obtained in Example I were observed.

It is claimed:

1. A process for metal plating which comprises spraying a mixture of metallic powder and small, solid peening particles at a high velocity against a surface, said velocity being sufficient to cause said small, solid peening particles to impact and mechanically bond said metallic powder onto said surface.

2. The process of claim 1 wherein the small, solid peening particles are selected from the group consisting of glass beads, metal shot, and ceramic beads.

3. The process of claim 1 wherein the spraying of the mixture of metallic powder and peening particles is effected by air or gas pressure.

4. The process of claim 1 wherein the metallic powder particle size is no larger than one half the peening particle size.

5. The process of claim 1 wherein said metallic powder comprises a mixture of dissimilar metallic powders or a mixture of at least one metallic powder with at least one non-metallic powder.

6. The process of claim 1 wherein the surface plated is selected from the group consisting essentially of metal, metal alloy, wood, plastic and ceramic substrates.

7. The process of claim 1, further comprising, prior to spraying said mixture against said surface, the steps of first preparing said surface to be plated by spraying said small, solid peening particles against said surface and then introducing said metallic powder to form said mixture of solid peening particles and metallic powder.

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8. The process of claim 7 wherein the surface to be plated is metal and the spraying in the absence of metallic powder is conducted at an angle to the surface and at a peening velocity sufficient to induce compressive stresses into said metal substrate.

9. The process of claim 7 wherein the peening particles are selected from glass beads, metal shot and ceramic beads.

10. A process for plating which comprises spraying, in the absence of heat, a mixture including at least one metallic powder and small, solid peening particles at a high velocity against a surface, said velocity being sufficient for said metallic powder to be pounded and bonded to said surface by said small, solid peening particles.

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