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(54) Hard anodize of cold spray aluminum layer

(57) A process for repairing components (60) includes the steps of providing a component (60) having an affected area (44) on a surface (45) of a component (60) to be repaired; depositing a repair material over the affected area (44) on the surface (45) of the component (60) so that the repair material plastically deforms without melting and bonds to the affected area (44) upon impact with the affected area (44) and thereby covers the affected area (44); providing a sulfuric acid based anodizing solution; anodizing a deposited repair material on the surface (45) of said component (60) in the sulfuric acid based anodizing solution; consuming only a portion of the deposited repair material to form a hard anodized coating layer upon the deposited repair material to form a hard anodized coated component (60); providing a corrosion resistant sealant solution; and contacting a hard anodized coated component with the corrosion resistant sealant solution to form a corrosion resistant sealant coating on the hard anodized coated component (60).

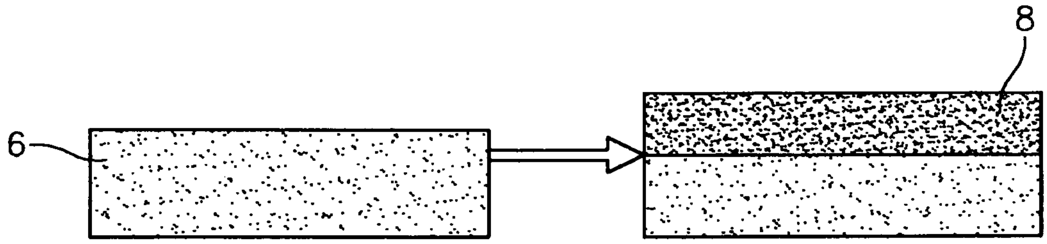

FIG. 1
(PRIOR ART)

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Description

FIELD OF THE DISCLOSURE

[0001] The invention relates to the field of repairing gas turbine components that have experienced corrosion damage and, more particularly, relates to methods that extend component life by reducing or eliminating further corrosion damage which could cause the component to be scrapped.

BACKGROUND OF THE DISCLOSURE

[0002] Gas turbine engine components, such as fan cases, bleed valves, bleed ducts, clamps, nacelle v-grooves, nacelle track sliders, gearboxes, and the like, are typically constructed of aluminum and magnesium alloys. Aluminum alloys such as AA 6061 and AA 2024 are soft and suffer damage via general wear, fretting against steel components, impact, etc. One method of mitigating wear of aluminum alloys is anodic conversion of the alloy to produce a hard oxide layer on the exposed surface per processes such as AMS 2468 or AMS 2469. There exist many means to dimensionally restore aluminum alloys; however, wear resistance is inferior to these hard anodic coatings.

[0003] Aluminum alloys are susceptible to general corrosion and especially salt (halide) environments and galvanic corrosion during regular service in the field. And, magnesium alloys, being typically less noble than aluminum alloys, are actually more susceptible to galvanic corrosion. For example, corrosion damage can be caused from electrical contact with a more noble alloy or by electrolytes in the presence of water or moisture. Environmental conditions such as chemical fallout, saltwater, and others can accelerate corrosion or add additional corrosion processes. Hard anodic layers provide some corrosion protection, especially when sealed with corrosion inhibiting materials, e.g., chromium conversion coatings.

[0004] There exists a drawback to hard anodizing processes. Hard anodizing processes consume part of the components' surface. The hard anodize process adds thickness to the surface, but the interface between anodize surface and parent alloy moves in to the parent material to approximately an equivalent thickness when forming a hard anodized layer 8 and repairing the component 6 (See FIG. 1). The rework of the anodic layer requires that all prior layer be removed. This limits the number of times the hard anodized layer may be applied in the rework and repair of the component. Magnesium alloys can be hard anodized, but the processes are substantially more difficult and expensive.

[0005] What is desired is a method of repairing gas turbine components that have suffered wear and corrosive deterioration by identifying and mitigating the corrosion attack before the component wall thickness has deteriorated below that required to provide minimum strength requirements, and restoring the original component dimensions while restoring original or offering added wear resistance and corrosion protection.

SUMMARY OF THE DISCLOSURE

[0006] In accordance with one aspect of the present disclosure, a process for repairing components, broadly comprises the steps of providing a component having an affected area on a surface of a component to be repaired; depositing a repair material over the affected area on the surface of the component so that the repair material plastically deforms without melting and bonds to the affected area upon impact with the affected area and thereby covers the affected area; providing a sulfuric acid based anodizing solution; anodizing a deposited repair material on said surface of said component in said sulfuric acid based anodizing solution; consuming only a portion of said deposited repair material to form a hard anodized coating layer upon said deposited repair material to form a hard anodized coated component; providing a corrosion resistant sealant solution; and contacting a hard anodized coated component with the corrosion resistant sealant solution to form a corrosion resistant sealant coating on the hard anodized coated component.

[0007] In accordance with another aspect of the present disclosure, a repaired component broadly comprises a component including a surface having a cold sprayed layer of repair material disposed thereupon, the component further includes an original thickness and the surface includes a restored thickness; and an anodized, hard coat disposed upon the cold sprayed layer, wherein the original thickness.is a thickness of the component prior to applying the cold sprayed layer and the restored thickness is the original thickness combined with a thickness of the cold sprayed layer.

[0008] The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a representation of a substrate surface being consumed during a hard anodizing process of the prior art.

FIG. 2 is a flowchart representing an exemplary process for the hard anodize of cold spray aluminum layer on a substrate;

FIG. 3 is a representation of a cold spraying deposition apparatus for use in the process described herein;

FIG. 4 are a set of four (4) microphotographs at different magnifications showing a comparison of a metallographic examination of the bond line between the cold spray layer and substrate of an anodized 6061 aluminum alloy plate cold sprayed with 6061 aluminum (unsealed);

FIG. 5 are a set of four (4) microphotographs at different magnifications showing a comparison of a metallographic examination of the bond line between the cold spray layer and substrate of an anodized 6061 aluminum alloy plate cold sprayed with 6061 aluminum (sealed) after undergoing salt fog testing (ASTM B-117) for approximately 336 hours;

FIG. 6 are a set of four (4) microphotographs at different magnifications showing a comparison of a metallographic examination of the junction area of a hard coating and the substrate of an 6061 aluminum alloy plate cold sprayed with 6061 aluminum after undergoing salt fog testing (ASTM B-117) for approximately 336 hours; and

FIG. 7 is a representation of an exemplary hard anodized component having a hard oxidized layer deposited upon a cold spray layer covering the surface of the component.

[0010] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0011] Over the last several years, a technique known as cold gas dynamic spraying ("cold spray") has been developed. This technique is advantageous in that it provides sufficient energy to accelerate particles to high enough velocities such that, upon impact during an initial pass, the particles plastically deform and bond to the surface of the component on which they are being deposited so as to build a relatively dense coating or structural deposit. On subsequent passes, the particles bond to the previously deposited layer. Cold spray does not metallurgically transform the particles from their solid state. The cold spray process has been found to be most useful in effecting repairs of components formed from ductile materials. For example, the cold spray process may be used during the repair of turbine engine components, such as a fan exit inner case or a gearbox, formed from aluminum or magnesium based materials. One such suitable cold spraying process is disclosed in U.S. Pat. Publ. No. 2006/0134320 to DeBiccari et al.

[0012] The process described herein restores the coating of an affected area on the surface of a component without consuming the surface, that is, the original thickness, of the component. As known to one of ordinary skill in the art, hard anodizing processes alone can consume parent alloy up to fifty percent (50%) of the anodic layer. The inventors of the present application discovered first depositing a repair material via, for example, cold spray deposition techniques, and then anodizing the repaired component actually preserved the original thickness of the component while in turn imparting wear resistance and corrosion protection. The inventors also discovered this process is effective for providing economical hard anodize protection to magnesium alloys. The hard anodic conversion processes are not easily or economically applied to magnesium alloys.

[0013] The inventors discovered by first applying cold sprayed aluminum to magnesium alloy based components, hard anodic conversion and chromate conversion coatings may be applied and the advantages and benefits achieved as disclosed herein. Moreover, there are benefits and advantages beyond the application to aluminum and magnesium based alloys. As the cold spray is a mechanical bonded substrate, the cold spray material may be applied to more expensive alloys or alloys known to be difficult to apply hard anodized coatings upon and be subsequently hard anodized more efficiently.

[0014] FIG. 2 shows a flowchart illustrating an exemplary process of the present disclosure.

[0015] A component composed of a magnesium alloy, aluminum alloy, conductive alloys, combinations comprising at least one of the foregoing alloys, and the like, and having an exterior surface is provided. Representative aluminum alloys for cold spray deposition include but are not limited to 1000 series, 5000 series and 6000 series. The component may be a gas turbine engine such as fan cases, bleed valves, bleed ducts, clamps, nacelle v-grooves, nacelle track sliders, gearboxes, and the like. The component may be inspected for damage at step 10 using any one of a number of techniques known to one of ordinary skill in the art. At the same time the material composition of the component may also be determined at step 12 using any one of a number of techniques known to one of ordinary skill in the art.

[0016] When repairing a turbine engine component, corrosion pits and/or damaged areas are mechanically removed (step 14) through grinding, machining, or other applicable techniques known to one of ordinary skill in the art. The resultant surface area may be cleaned using a chemical based cleaning technique (step 16) known to one of ordinary skill in the art. Afterwards, the chemically cleaned surface area of the component may be prepared for cold spray deposition (step 18) using a grit blasting technique known to one of ordinary skill in the art.

[0017] Referring now to FIG. 3, there is shown a system for carrying out a cold spray process on an affected area 44 of a component or a part. A representative cold spray process is disclosed in United States Patent Publication No. 2009/0011123 to Bunting et al.. Another representative process is disclosed in United States Patent Publication No. 2006/0134320 to DeBiccari et al..

[0018] The system includes a spray gun 42 having a converging/diverging nozzle 40 through which the repair material is sprayed onto an affected area of a surface 45 of the component 60 to be repaired. During deposition of the repair material, the component 60 may be held stationary or may be articulated or translated by any suitable means (not shown) known in the art. Alternatively, spray nozzle 40 may be held stationary or may be articulated or translated. In some situations, both the part and the nozzle may be manipulated.

[0019] Suitable aluminum containing materials which may be used to effect repairs in accordance with the process described herein, but are not limited to, pure aluminum, aluminum alloy 6061, aluminum alloy 2219, Al-12Si alloy, Al-Sc alloy, aluminum alloy 6061/B4C, and aluminum alloy 5056. In a preferred embodiment of the present invention, the aluminum containing material comprises a material which has a composition that includes more than 50% by weight of aluminum.

[0020] In the cold spray process described herein, the repair material feedstock may be a powdered aluminum containing material 51. The powdered aluminum containing material may be a powdered aluminum containing material of -325 mesh with particle sizes in the range of from 5 microns to 50 microns. Smaller particle sizes such as those mentioned before enable the achievement of higher particle velocities. Below 5 microns in diameter, the particles risk getting swept away from the surface 45 and/or the affected area 44 due to a bow shock layer above the surface 45 and/or the affected area 44. This is due to insufficient mass to propel the particles through the bow shock. The narrower the particle size distribution, the more uniform the particle velocity will be. This is because if one has large and small particles (bi-modal), the small ones will hit the slower, larger ones and effectively reduce the velocity of both.

[0021] The fine particles of the aluminum containing repair material may be accelerated to supersonic velocities using compressed gas, such as helium, nitrogen, or other inert gases, and mixtures thereof. Helium and nitrogen are preferred gases because both helium and nitrogen produce the highest velocity due to their low molecular weights.

[0022] The bonding mechanism employed by the method of the present invention for transforming the powdered aluminum containing repair material into a deposit is strictly solid state, meaning that the particles plastically deform. Any oxide layer that is formed on the particles and/or on the component surface is broken up and fresh metal-to-metal contact is made at very high pressures.

[0023] The powdered aluminum containing repair material used to form the deposit may be fed to the spray gun 42 using any suitable means known in the art, such as modified thermal spray feeders. For example, a Praxair® powder feeder at a wheel speed of 1-5 rpm may be used.

[0024] In the process described herein, the feeder may be pressurized with a gas 53 selected from the group consisting of helium, nitrogen, or other inert gases, and mixtures thereof. For example, the feeder may be pressurized using helium at a pressure in the range from 200 psi (1.38 MPa) to 400 psi (2.76 MPa), preferably from 300 to 350 psi (2.07 to 2.41 MPa). The main gas is preferably heated so that the gas temperatures is in a range from 250°C (482°F) to 550°C (1022°F), preferably from 350°C (662°F) to 450°C (842°F). In the alternative, the feeder may be pressurized using nitrogen gas at a pressure in a range from 400 psi (2.76 MPa) to 600 psi (4.14 MPa), preferably from 500 psi (3.45 MPa) to 550 psi (3.79 MPa). When using nitrogen gas, the main gas is also preferably heated so that the gas temperature is in a range from 250°C (482°F) to 550°C (1022°F), preferably from 350°C (662°F) to 450°C (842°F).

[0025] The gas may be heated to keep it from rapidly cooling and freezing once it expands past the throat of nozzle 20. The net effect is a surface temperature on the part being repaired of about 46°C (115°F) during deposition. Any suitable means known in the art may be used to heat the gas.

[0026] To deposit the aluminum containing repair material, the nozzle 40 may pass over the affected area 44 of the part 60 being repaired more than once. The number of passes required is a function of the thickness of the repair material to be applied. The method of the present invention is capable of forming a deposit having any desired thickness. If one wants to form a thick layer, the spray gun 42 may be held stationary to form a thick deposit over the affected area 44. When building a deposit layer of the aluminum containing repair material, it is desirable to limit the thickness per pass in order to avoid a quick build up of residual stresses and unwanted debonding between deposit layers.

[0027] The main gas that is used to deposit the particles of the repair material over the affected area 44 may be passed through the nozzle 40 via an inlet 50 at a flow rate of 0.001 SCFM (0.028 1/min) to 60 SCFM (1699 1/min), preferably in the range of 15 SCFM (425 l/min) to 50 SCFM (1416 l/min). The foregoing flow rates are useful when either helium or nitrogen is used as the main gas.

[0028] The pressure of the spray gun 42 may be in the range of from 200 psi (1.38 MPa) to 400 psi (2.76 MPa), preferably from 300 psi (2.07 MPa) to 350 psi (2.41 MPa). The powdered aluminum containing repair material is preferably fed from a hopper, which is under a pressure in the range of 10 to 50 psi (68.9 to 344.7 kPa) higher than the specific main gas pressure, preferably 15 psi (103.4 kPa) higher to the spray gun 42 via line 54 at a feed rate in the range of 10 grams/min to 100 grams/min, preferably 15 grams/min to 50 grams/min.

[0029] The powdered aluminum containing repair material is preferably fed to the spray gun 42 using a non-oxidizing carrier gas. The carrier gas may be introduced via inlet 50 at a flow rate of 0.001 SCFM (0.028 1/Min) to 50 SCFM (1416 1/Min), preferably 1 SCFM (28.3 l/Min) to 15 SCFM (425 1/Min). The foregoing flow rates are useful when either helium or nitrogen is used as the carrier gas.

[0030] The spray nozzle 20 is held at a distance from the affected area 24. This distance is known as the spray distance. Preferably, the spray distance is in the range of 10 mm to 50 mm. The velocity of the powdered repair material particles leaving the spray nozzle 20 may be in a range from 825 m/s to 1400 m/s, preferably from 850 m/s to 1200 m/s. The deposit thickness per pass may be in the range of 0.001 inches (0.0254 mm) to 0.030 inches (0.762 mm).

[0031] Using the process described herein, the aluminum containing repair material, such as aluminum alloy 6061, may be cold sprayed (step 20) over the affected area on the component 60 to a thickness above the original wall thickness. After the aluminum containing material has been deposited, the component 60 may undergo stress relief, for example, heat treatment, at step 22 as known to one ordinary skill in the art.

[0032] Stress relief techniques are typically performed to recover the ductility of the cold sprayed aluminum containing repair material. The stress relief step may be carried out at a temperature which achieves the desired ductility for the component 60. For example, the heat treatment may be one in which the component with the cold sprayed aluminum containing material deposit is heated in an air oven to a temperature of 260°C (500°F) for a time period of 1 hour to 2 hours. When some aluminum containing repair materials are used, no heat treatment may be needed. When other aluminum containing repair materials are used, the heat treatment may be at a temperature which varies from 38°C (100°F) to a temperature greater than 260°C (500°F) for a time period in the range of 1 hour to 24 hours. When the component requires undergoing stress relief, the entire component, or the local area of the repair, may be treated.

[0033] After step 22 is completed, the cold spray layered component 60 with the deposited repair material may be mechanically smoothed in the region of the affected area 44 and structural credit may be claimed for the repaired area. Structural credit as used herein refers to the fact that the cold sprayed aluminum alloy repair material has a percentage of the base material strength and repaired thickness is considered as part of the measured wall thickness. The cold spray layered component 60 may be preliminarily inspected to determine whether the wear resistance is sufficient at step 24. Any one of a number of suitable techniques for determining wear resistance known to one of ordinary skill in the art may be utilized.

[0034] It is not necessary that the deposits of the cold sprayed aluminum containing repair material have parent metal strength, only that the structural credit be sufficient such that the effective wall thickness is above the required minimum. If the effective wall thickness is above the required minimum, the component 60 can be salvaged. As used herein, the term effective wall thickness means that if one considers the sprayed deposit to have say 75% of the strength of the base material forming the component 60, then the repair thickness is credited 75%. Thus, if the current wall thickness of the component 60 is 0.100 inches (2.54 mm) and a deposit of 0.050 inches (1.27 mm) is applied to make total thickness of 0.150 inches (3.81 mm), the effective wall thickness of the repair is 0.1375 inches (3.49 mm) since the repair material has 75% of the strength of the base material of the component. Of course it should be understood that the figure given herein (75%) is merely exemplary to illustrate the general principle.

[0035] If the component 60 demonstrates sufficient wear resistance, the component 60 may undergo a final inspection at step 32. However, if the component 60 does not demonstrate sufficient wear resistance, the cold sprayed aluminum layered component 60 then undergoes an anodizing process. The cold sprayed aluminum layered component 60 may be treated to remove grease, if necessary, from the cold spray layer as known to one of ordinary skill in the art. The optional grease removal step may be done, if necessary, prior to anodizing the cold sprayed aluminum layer.

[0036] The term "anodized aluminum" as used herein refers to aluminum and its alloys which have been subjected to the anodizing process to produce adherent aluminum oxide (Al_2O_3) coatings thereon. Such aluminum oxide coatings provide hard and strong protective coatings and protect against corrosion and abrasion as well as strengthen the coated articles and provide electrical insulation thereon. Presently, the process described herein subjects the deposited cold sprayed aluminum layer to an anodizing process (step 26) known to one of ordinary skill in the art.

[0037] The anodizing process comprises anodizing the metal substrate in a sulfuric acid based anodizing solution, preferably a sulfuric oxalic acid anodizing solution, at step 26. The deposited cold sprayed aluminum layer may be subjected to a sulfuric oxalic acid anodize by any manner as known to one of ordinary skill in art. The anodizing process forms a hard oxide layer 70 upon a cold spray layer 68 of component 60 without consuming the parent alloy and only consuming a portion of the cold spray layer 68 (See Fig. 7). The hard.anodized component 60 may be preliminarily inspected to determine whether the corrosion resistance is sufficient at step 28. Sufficient corrosion resistance may be determined using any one of a number of techniques known to one of ordinary skill in the art. If the hard anodized component 60 demonstrates sufficient corrosion resistance, the hard coated component 60 may then undergo a final inspection at step 32. However, if the hard anodized component 60 does not demonstrate sufficient corrosion resistance, the hard coated component 60 may then undergo a corrosion resistant sealant process at step 30.

[0038] During an exemplary chromate conversion process, the hard coated component 60 may be contacted with an acidic trivalent chromium containing solution to form a trivalent chrome enriched coating upon the anodized component. The acidic aqueous solution comprises a water soluble trivalent chromium compound, a water soluble fluoride compound and an alkaline reagent. A representative acidic aqueous solution may comprise a trivalent chromium compound is present in an amount of between 0.2 g/liter to 5 g/liter (preferably between 0.5 g/liter to 2 g/liter), a fluoride compound is present in an amount of between 0.2 g/liter to 5 g/liter (preferably 0.5 g/liter to 2 g/liter), and an alkaline reagent is present in an amount to maintain the pH of the solution between 3.0 to 5.0 (preferably 3.5 to 4.0). In the alternative, water soluble molybdenum compound may be substituted for the trivalent chromium compound as such molybdenum compounds may also be utilized as corrosion resistant sealants. The solution may be applied or contacted upon the hard coated component 60 using any one of a number of processes including but not limited to immersion, spraying, painting, and the like as known to one of ordinary skill in the art.

EXPERIMENTAL SECTION

[0039] Seven (7) panels of cold sprayed aluminum alloy 6061 on standard aluminum alloy 6061 (Panels 1-7) were processed to determine whether or not the cold spray coating responds differently to processing. Tests performed on the hard anodized panels per AMS 2469 were salt fog per ASTM B-117, bond strength, and microstructural evaluation.

[0040] A small section of each Panel 1-7 was removed to perform metallographic examination of the bond line between the cold spray aluminum 6061 layer and aluminum alloy 6061 substrate and the microstructural comparison between the two (See Panel 1 of Fig. 4). Panels 1-7 submitted for anodized hard anodize were non-standard size for subsequent salt fog testing ASTM B-117. Panels 1-7 were hard anodized per AMS 2469 (See Fig. 5). Metallographic evaluation of the junction area of the anodized hard coating and substrate did not reveal any evidence of crevice corrosion after salt fog exposure (See Fig. 6).

[0041] Tensile bond tests were performed on each Panel 1-7 using Scotchweld 2214 non-metallic filled epoxy, having a cure less than 300°F (149°C). The average ultimate strength (PSI) of each Panel 1-7. was 7,825 psi with 100% rupture in the epoxy. These results are indicative of a good bond between the coating and aluminum alloy 6061 panel and exceed the PWA 53-11 requirements of an average ultimate tensile bond strength of at least 5000 psi.

[0042] The chemistry of the cold sprayed aluminum alloy 6061 deposited material was the same as standard aluminum alloy 6061 material of the panels. However, the metallurgical structure was different between the cold sprayed aluminum alloy layer and the parent aluminum alloy panel. The cold sprayed aluminum alloy layer responded to the hard anodize process the same as the parent aluminum alloy. Satisfactory coatings were generated using typical 6061 parameters and there was no noticeable difference in the coating in the interface where the base 6061 material and the cold sprayed 6061 met. There was no discernible loss in salt fog test performance and no difference at the interface of the base metal and coating. Hardness measurements in the hard anodized area as well as the base material and cold sprayed material were consistent with normal readings for this material. The tensile bond strength specimens all failed in the epoxy indicative of good adhesion of the coating. These tests confirmed that hard anodize of cold sprayed aluminum alloy 6061 is a viable candidate for repairing aluminum structures.

[0043] One or more embodiments of the present invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

Claims

1. A process for repairing components (60), comprising the steps of:

    providing a component (60) having an affected area (44) on a surface (45) of a component(60) to be repaired;
    depositing a repair material over said affected area (44) on said surface (45) of said component so that said repair material plastically deforms without melting and bonds to said affected area upon impact with said affected area (44) and thereby covers said affected area (44);
    providing a sulfuric acid based anodizing solution;
    anodizing a deposited repair material on said surface (45) of said component (60) in said sulfuric acid based anodizing solution;
    consuming only a portion of said deposited repair material to form a hard anodized coating layer upon said deposited repair material to form a hard anodized coated component (60);
    providing a corrosion resistant sealant solution; and
    contacting a hard anodized coated component with the corrosion resistant sealant solution to form a corrosion resistant sealant coating on the hard anodized coated component (60).

2. The process of claim 1, wherein said repair material comprises any one of the following: pure aluminum, aluminum alloy 6061, aluminum alloy 2219, aluminum alloy 5056, Al-12Si alloy, Al-Sc alloy, and aluminum alloy 6061/B4C.

3. The process of claim 1 or 2, wherein depositing said repair material comprises cold spraying said repair material.

4. The process of any preceding claim, wherein said depositing step comprises providing said repair material in powder form having a particle size in the range of from 5 microns to 50 microns.

5. The process of any preceding claim, wherein said depositing step further comprises accelerating said powder particles to a speed in the range of from 825 m/s to 1400 m/s.

6. The process of any preceding claim, further comprising mechanically removing at least one of corrosion pits and damaged areas from said affected area (44) on said component (60) prior to performing said depositing step.

7. The process of claim 6, further comprising chemically cleaning said affected area (44) on said component (60) after said removal step.

8. The process of claim 7, further comprising grit blasting a chemically cleaned affected area of said component (60) after said cleaning step.

9. The process of any preceding claim, further comprising stress relieving said component with said deposited repair material at a temperature and for a time sufficient to recover ductility for said deposited aluminum containing repair material prior to performing said anodizing step.

10. The process of any preceding claim, further comprising determining a wear resistance of said deposited repair material on said surface (45) of said component (60) prior to performing said anodizing step.

11. The process of claim 10, further comprising performing a final inspection of said component (60).

12. The process of claim 10 or 11, further comprising determining a corrosion resistance of said anodized component prior to providing said corrosion resistant sealant solution.

13. The process of any preceding claim, wherein providing said corrosion resistant sealant solution comprises providing a chromate conversion solution or a molybdenum conversion solution.

14. A repaired component (60), comprising:

a component (60) including a surface (45) having a cold sprayed layer of repair material disposed thereupon, said component (60) further includes an original thickness and said surface includes a restored thickness; and
an anodized, hard coat disposed upon said cold sprayed layer,

wherein said original thickness is a thickness of said component prior to applying said cold sprayed layer and said restored thickness is said original thickness combined with a thickness of said cold sprayed layer.

15. The repaired component of claim 14, wherein said component (60) comprises any one of the following: aluminum alloy, a magnesium alloy, conductive alloy and combinations thereof.

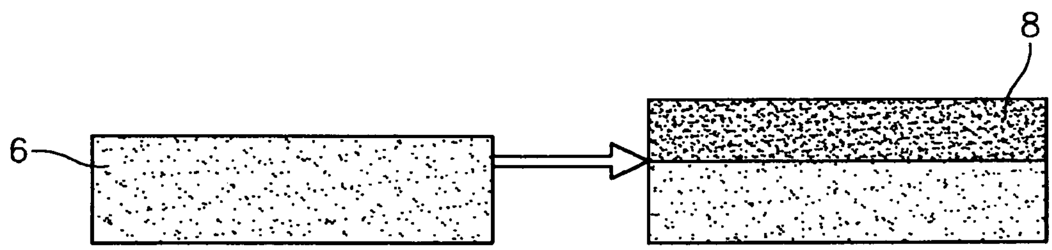
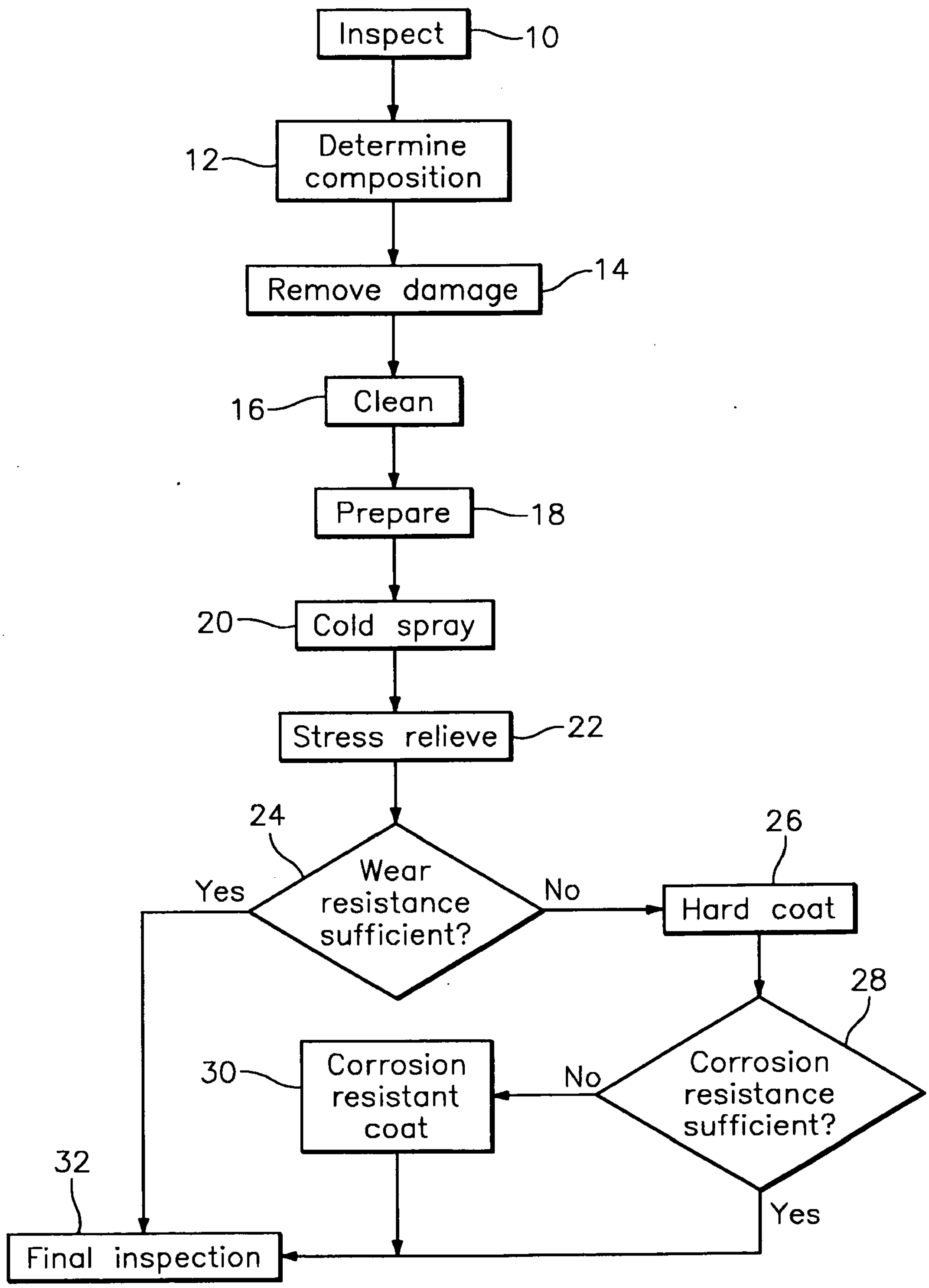


FIG. 1
(PRIOR ART)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12
Determine composition
Remove damage
14
16
Clean
Prepare
18
20
Cold spray
Stress relieve
22
24
26
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Hard coat
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Corrosion resistant coat
No
Corrosion resistance sufficient?
32
Yes
Final inspection

FIG. 2

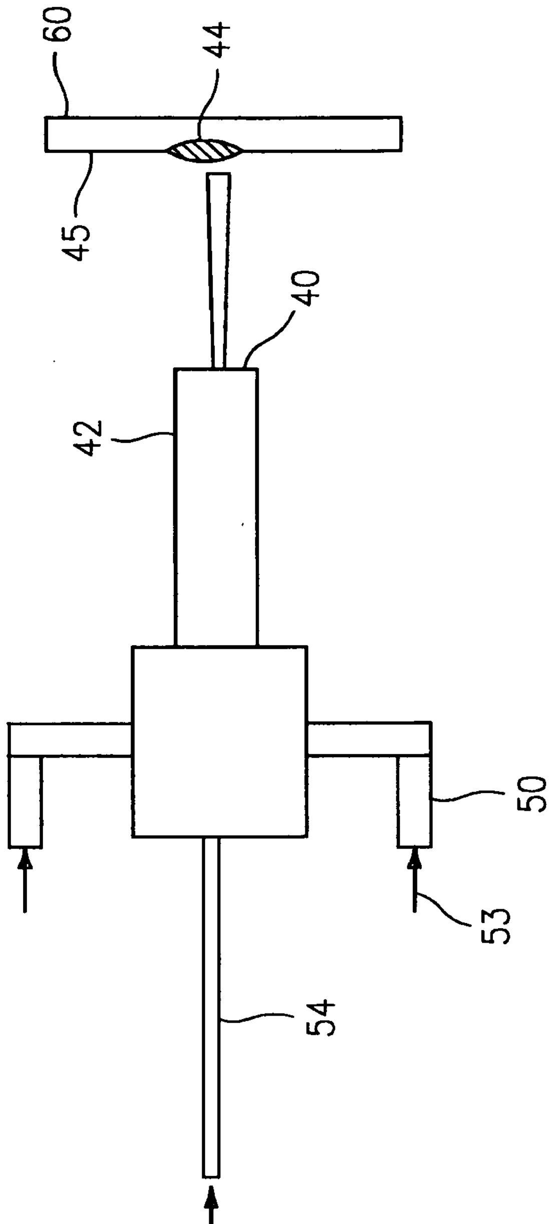

FIG. 3

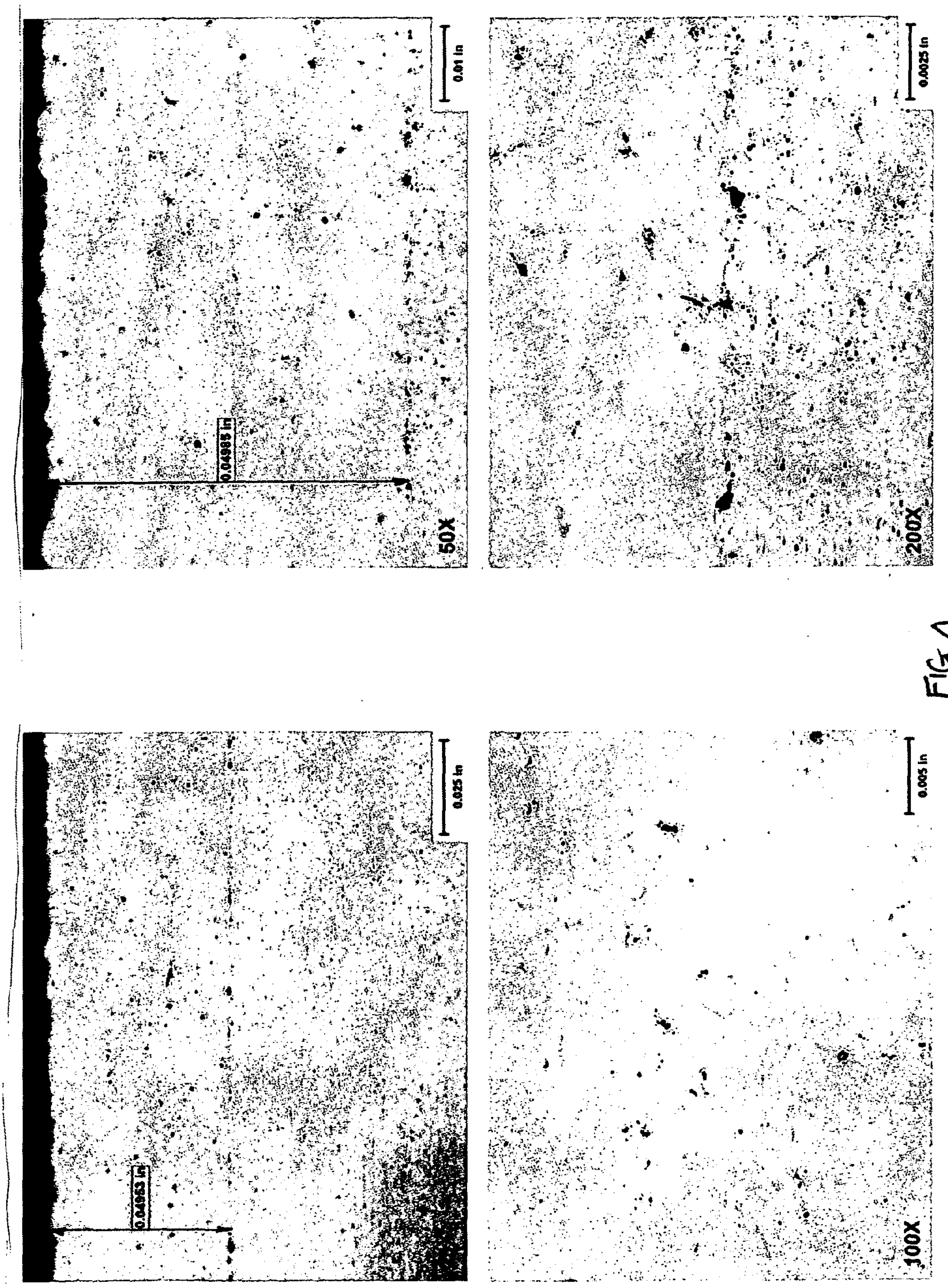
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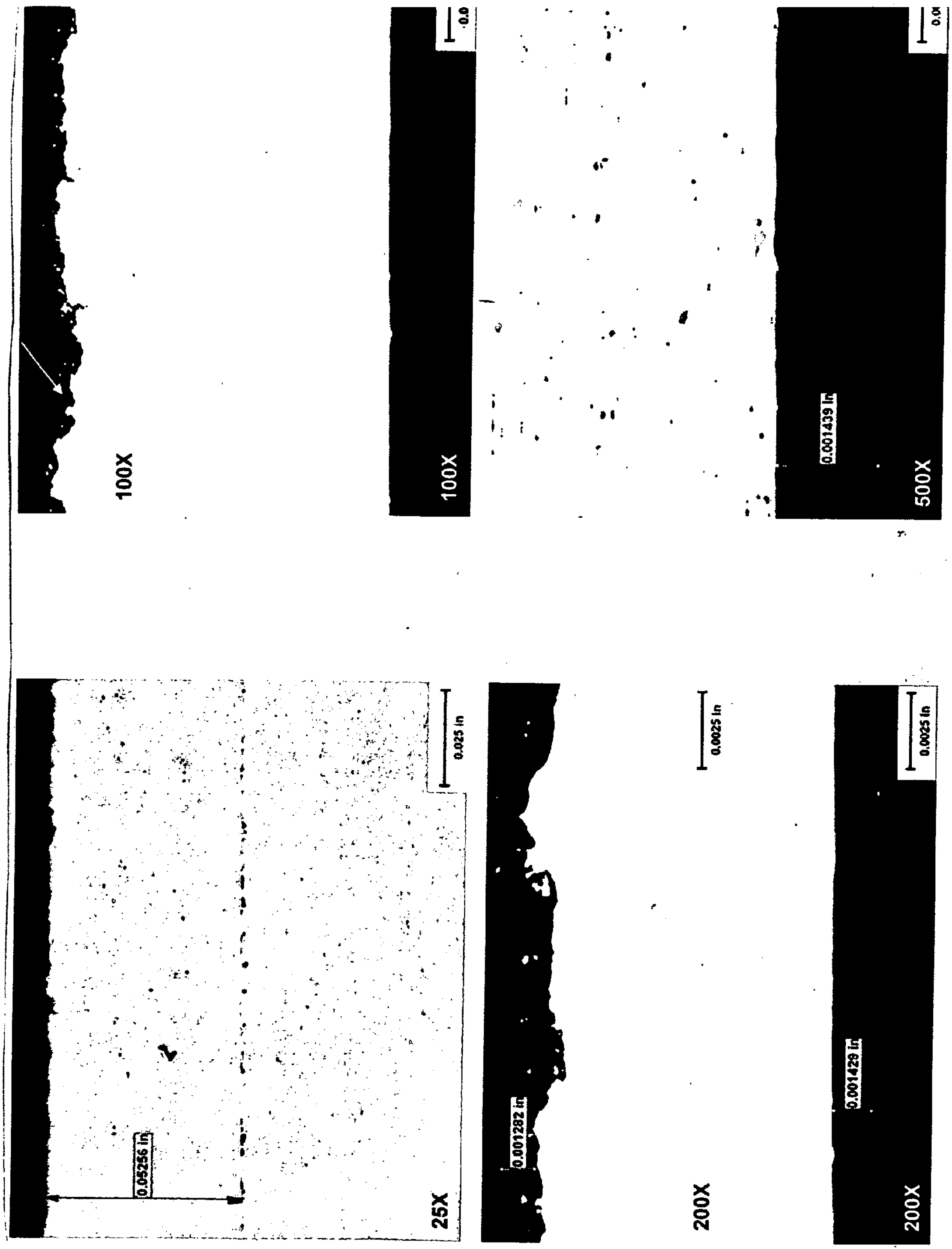
FIG 4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200X

FIG 5

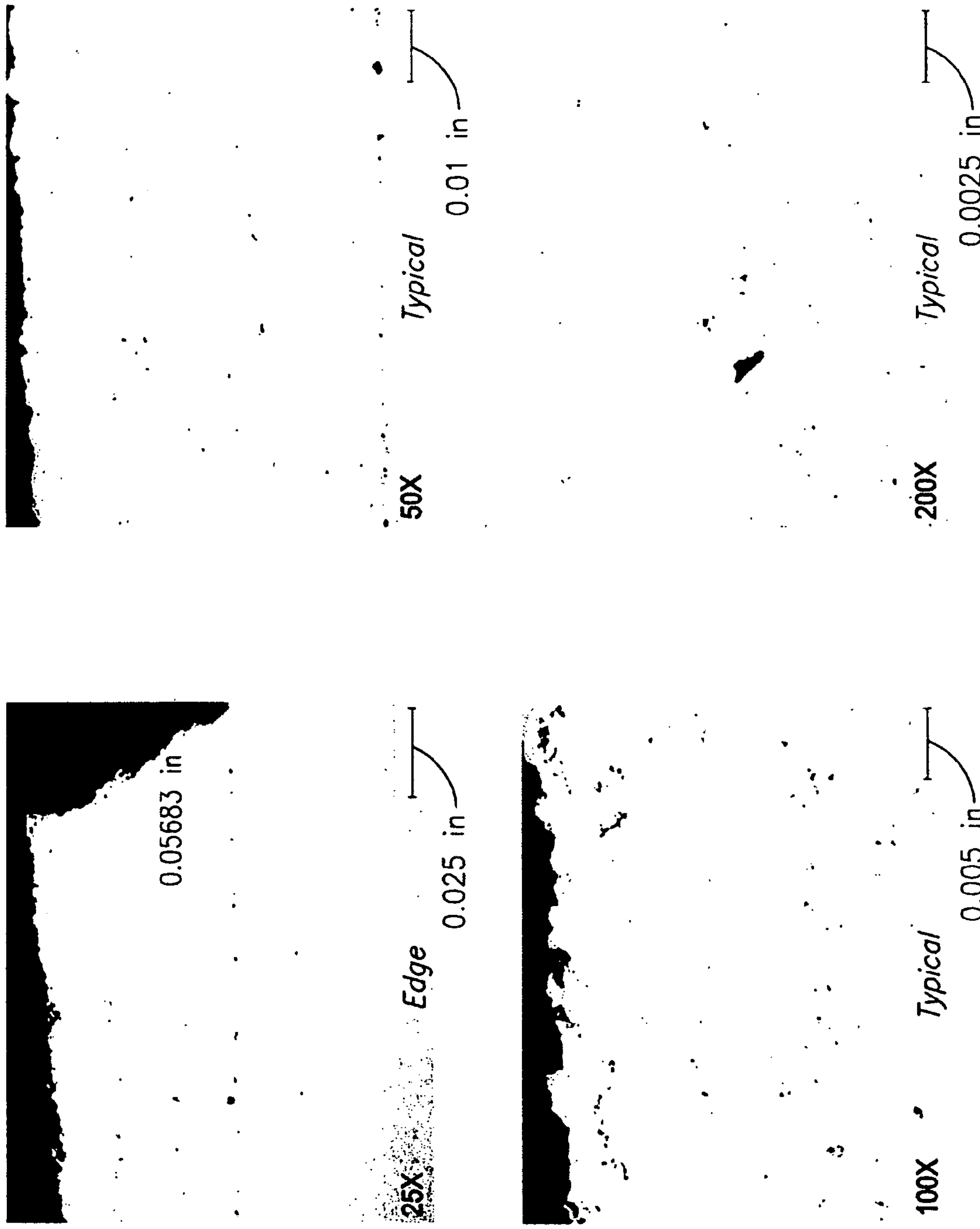
0.05683 in
25X
Edge
0.025 in
50X
Typical
0.01 in
100X
Typical
0.005 in
200X
Typical
0.0025 in

FIG. 6

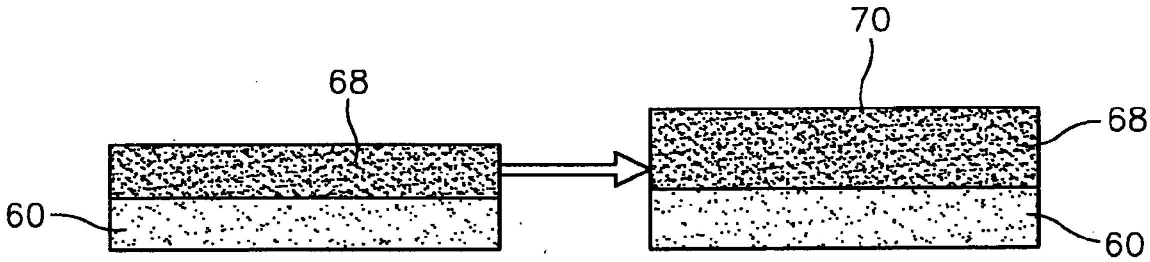

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 20090011123 A, Bunting **[0017]**