Jan. 3, 1967 J. E. SPELLMAN 3,295,941

DIAMOND REINFORCED COATINGS AND METHOD OF PREPARING SAME

Filed June 26, 1963

Fig. 1.

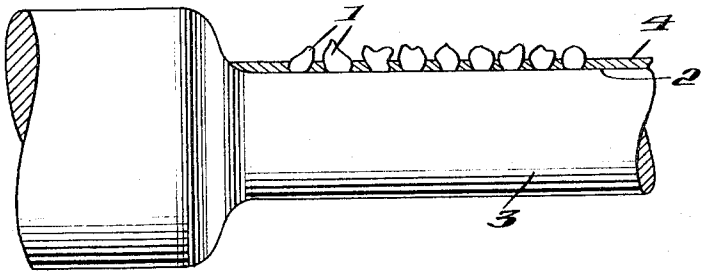


Fig. 2.

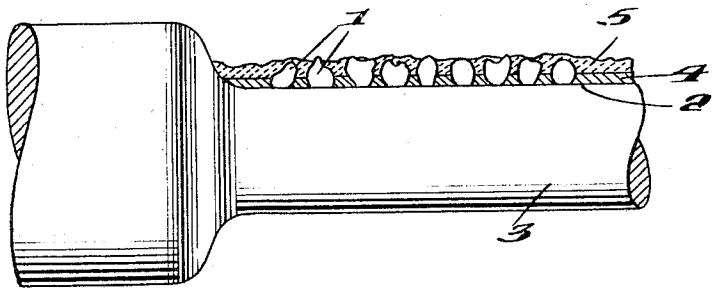
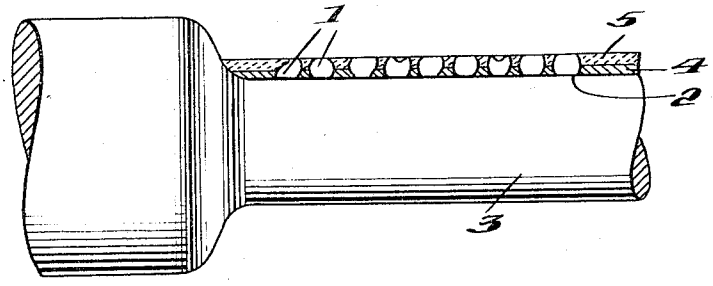


Fig. 3.



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DIAMOND REINFORCED COATINGS AND METHOD OF PREPARING SAME

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This invention relates to an article of manufacture and process. More particularly, it concerns an article of manufacture provided with an improved wear-resistant surface, and to a novel process for forming said wear-resistant surface.

It is a common industrial problem that metallic workpieces lack adequate wear resistance. Many methods have been evolved to harden their surfaces in order to extend their life. When especially high resistance to wear is required, as when the metallic parts are required to be in motion with respect to abrasive materials, one such method is to coat one of the many known, hard, wear-resistant surfaces onto the surface or incorporate the hard material into the surface. However, practical difficulties encountered in the preparation of such surfaces include structural weakness of the coating and lack of adequate bonding to the metallic article.

It is an object of the present invention to provide an article having a highly wear-resistant surface.

Another object is to provide an article having a wear-resistant surface of high mechanical strength firmly bonded to the article.

Another object is to provide a novel process for forming such a wear-resistant surface on an article.

These and other objects will become apparent in the course of the following specification and claims.

The objects of this invention are accomplished by providing an article of manufacture which comprises, in combination, a member having a solid surface and a wear-resistant coating positioned on said solid surface, said coating comprising diamond particles, a metal matrix, and a ceramic matrix, the outer surface of said coating being substantially smooth and having portions of at least a substantial proportion of said diamond particles exposed.

With reference to the method aspect of the disclosure, the primary object of the invention is to provide an improved method for forming upon a member having a solid surface an abrasive layer consisting of diamond particles, each of said particles being of substantially the same particle size and being positioned at substantially regularly spaced locations on said solid surface, secured first by electro-deposition within a hard metal matrix having a depth substantially one-half the average particle size of the diamonds and secured second by spraying a continuous hard ceramic metallic oxide coating upon the said metal matrix until the diamonds are substantially covered by the ceramic coating and grinding the coating smooth until portions of at least a substantial proportion of said diamond particles are exposed.

The invention will be more fully understood by reference to the accompanying drawing in which:

FIGURE 1 illustrates an early stage in the provision of the wear surface of the invention on a steel shaft;

FIGURE 2 illustrates an intermediate stage in the manufacture of the wear-resistant surface; and

FIGURE 3 illustrates an embodiment of the apparatus of the invention comprising a shaft having the novel wear-resistant surface in its finished form.

In FIGURE 1 is illustrated a single layer of closely-spaced diamond particles 1, graded within a relatively narrow range of particle sizes so that each is of substantially the same size, bonded to surface 2 of conventional metal member 3 by electrodeposition of a metal matrix 4

around and about the diamond particles to a depth approximating one-half of the average particle size of the diamonds. Conventional methods for electro-plating diamonds upon metallic members, e.g., as described by Seligman et al. in U.S. Patent 2,360,798 and by Brenner in U.S. Patent 2,411,867, may be employed to form the diamond-studded surface on the member 3 of FIGURE 1.

FIGURE 2 illustrates the diamond-studded member 3 of FIGURE 1 after deposition of a continuous hard ceramic coating 5 upon the diamond particles and the metal matrix surrounding the particles, the depth of the hard ceramic coating being sufficient to cover or substantially cover all of the diamond particles. Conventional methods for flame-spraying metallic oxide ceramic materials, e.g., the plasma method or rod method or particularly the detonation-gun method as described in Machine Design, vol. 33, No. 18, August 31, 1961, pages 82–92, may be employed to form the coating on the member 3 of FIGURE 2.

In FIGURE 3 is shown the ceramic-coated member of FIGURE 2 after the surface is finished by grinding or lapping until the diamond particles are exposed, the exposed portion of the diamond particles and the hard ceramic coating each being substantially smooth and forming together a continuous, substantially smooth surface. Conventional diamond-wheel grinding procedures may be employed for finishing the ceramic-coated, diamond-studded member.

Although steel is the metal which is probably most commonly employed to make metal members of the type contemplated herein, other metals may be employed with equal facility, a few examples being aluminum, copper and titanium. The metal matrix may be formed by electro-deposition of nickel, chromium, copper or any other suitable metal. The hard ceramic coating may be applied by flame spraying aluminum oxide, chromium sesquioxide, beryllium oxide, silicon dioxide, zirconium oxide, stannic oxide, titanium oxide or any other hard ceramic material including suitable mixtures containing metallic oxides.

In an actual demonstration of the utility of the present invention, a steel pump shaft having the configuration shown in FIGURE 1 was plated with a single layer of diamond particles having a particle size range of 0.003 to 0.004 inch by electro-deposition of a matrix of nickel about the diamond particles to a height of 0.0015 inch. Chromium sesquioxide was then flame-sprayed from a detonation gun onto the diamond-studded shaft until the layer of diamond particles was covered by a uniform, continuous hard ceramic coating. The coating was then lapped with a 120-grit, metal-bonded diamond wheel, grinding the rough oxide coating and the diamond points to a smooth, continuous surface having a surface roughness of only 15 to 20 R.M.S. microinches. The finished shaft was mounted in a pump employed for pumping an abrasive slurry comprising a 30% aqueous dispersion of sand. It was found that the pump could be employed for 7 weeks before removal was necessary due to wear; while under identical conditions an untreated steel shaft became too worn to permit continued operation within the space of a week.

Other obvious advantages of this invention are the savings in downtime of the equipment and the other multiple economic advantages derived therefrom.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

What is claimed is:

1. An article of manufacture which comprises, in combination, a member having a solid surface and a wear-

resistant coating positioned on said solid surface, said coating comprising diamond particles each of said particles being of substantially the same particle size and being positioned at substantially regularly spaced locations on said solid surface, said diamond particles being embedded, first, in a metal matrix and second, in a ceramic matrix selected from the group consisting of aluminum oxide, chromium sesquioxide, beryllium oxide, silicon dioxide, zirconium oxide, stannic oxide, titanium oxide, and mixtures thereof, said ceramic matrix being of substantially uniform thickness in the regions between said diamond particles, the outer surface of said coating being substantially smooth and having portions of at least a substantial proportion of said diamond particles exposed.

2. The method of forming upon the surface of a member an abrasive layer consisting of diamond particles, each of said particles being of substantially the same particle size, said method comprising positioning said particles at substantially regularly spaced locations on said solid surface, securing said particles first by electro-deposition within a hard metal matrix having a depth of substantially one-half the average particle size of the diamonds and securing said particles second by spraying a continuous hard ceramic oxide coating selected from the group consisting of aluminum oxide, chromium sesquioxide, beryllium oxide, silicon dioxide, zirconium oxide, stannic oxide, titanium oxide, and mixtures thereof, upon the said metal matrix until the diamonds are substantially covered by the ceramic coating, and grinding the ceramic coating smooth until portions of at least a substantial proportion of said diamond particles are exposed.

3. An article of manufacture which comprises a member and a wear-resistant coating positioned on the surface of said member; said coating comprising a metal matrix, a ceramic matrix selected from the group consisting of aluminum oxide, chromium sesquioxide, beryllium oxide, silicon dioxide, zirconium oxide, stannic oxide, titanium oxide, and mixtures thereof as the outermost layer, and diamond particles embedded in the said metal and ceramic matrices, said outermost layer being of substantially uniform thickness in the regions between said diamond particles, and the outer surface of said coating being substantially smooth and having portions of at least a substantial proportion of said diamond particles exposed.

4. The article of manufacture of claim 3 wherein said metal matrix is nickel.

5. The article of manufacture of claim 3 wherein said ceramic matrix is chromium sesquioxide.

6. The article of manufacture of claim 3 wherein said matrix is aluminum oxide.

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