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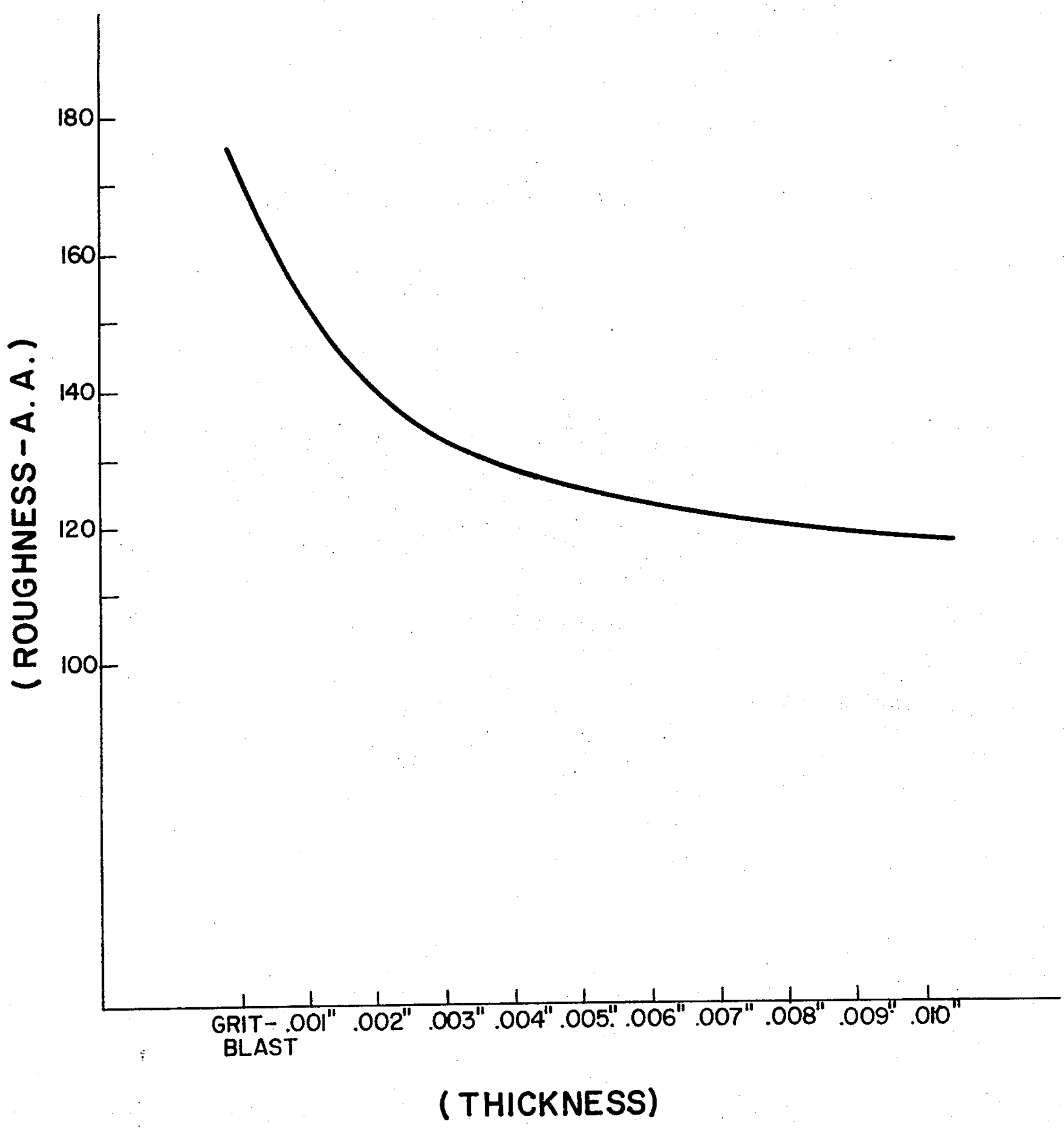
July 25, 1972 E. D. REID 3,679,460

COMPOSITE WEAR RESISTANT MATERIAL AND METHOD OF MAKING SAME

Filed Oct. 8, 1970 4 Sheets-Sheet 1



F I G. 1.

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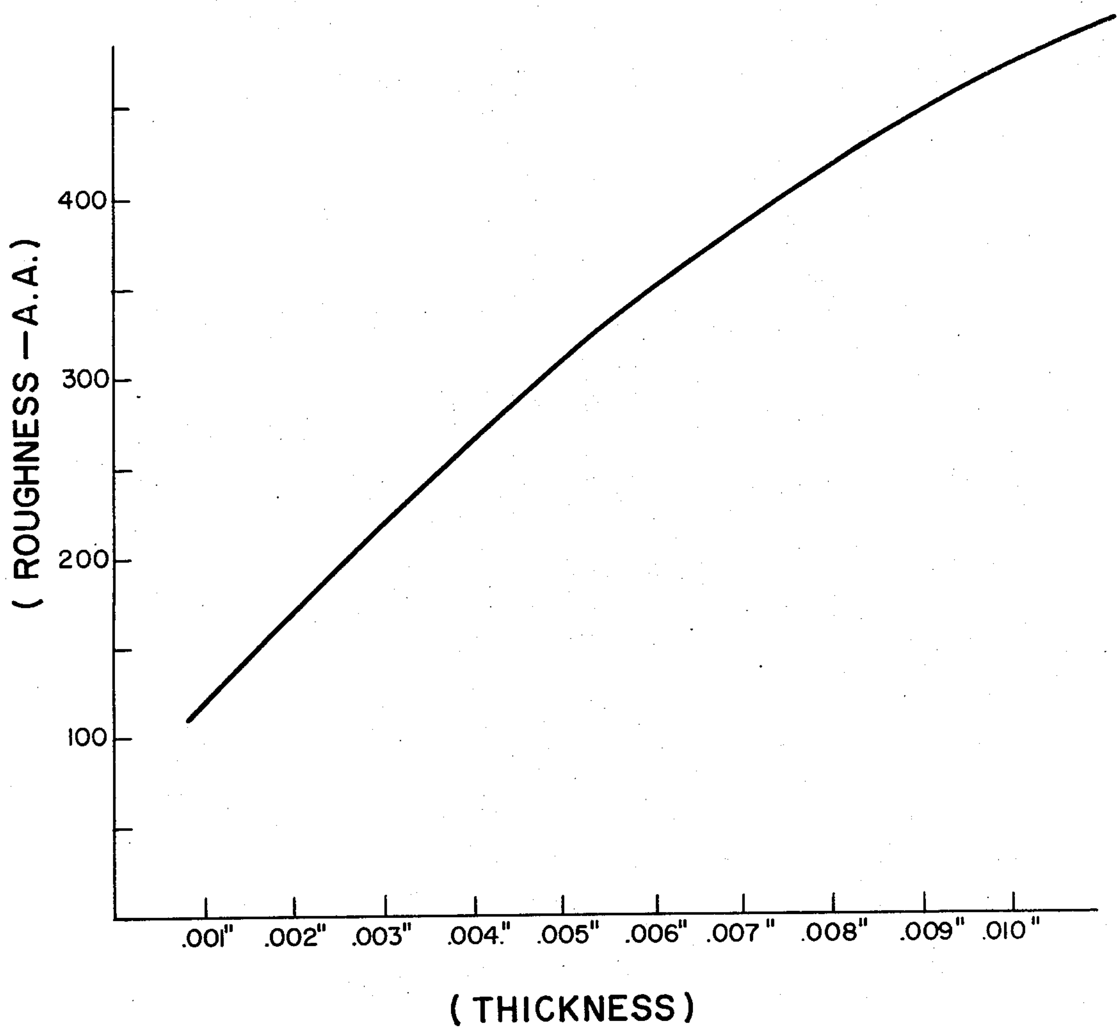

F I G. 2.

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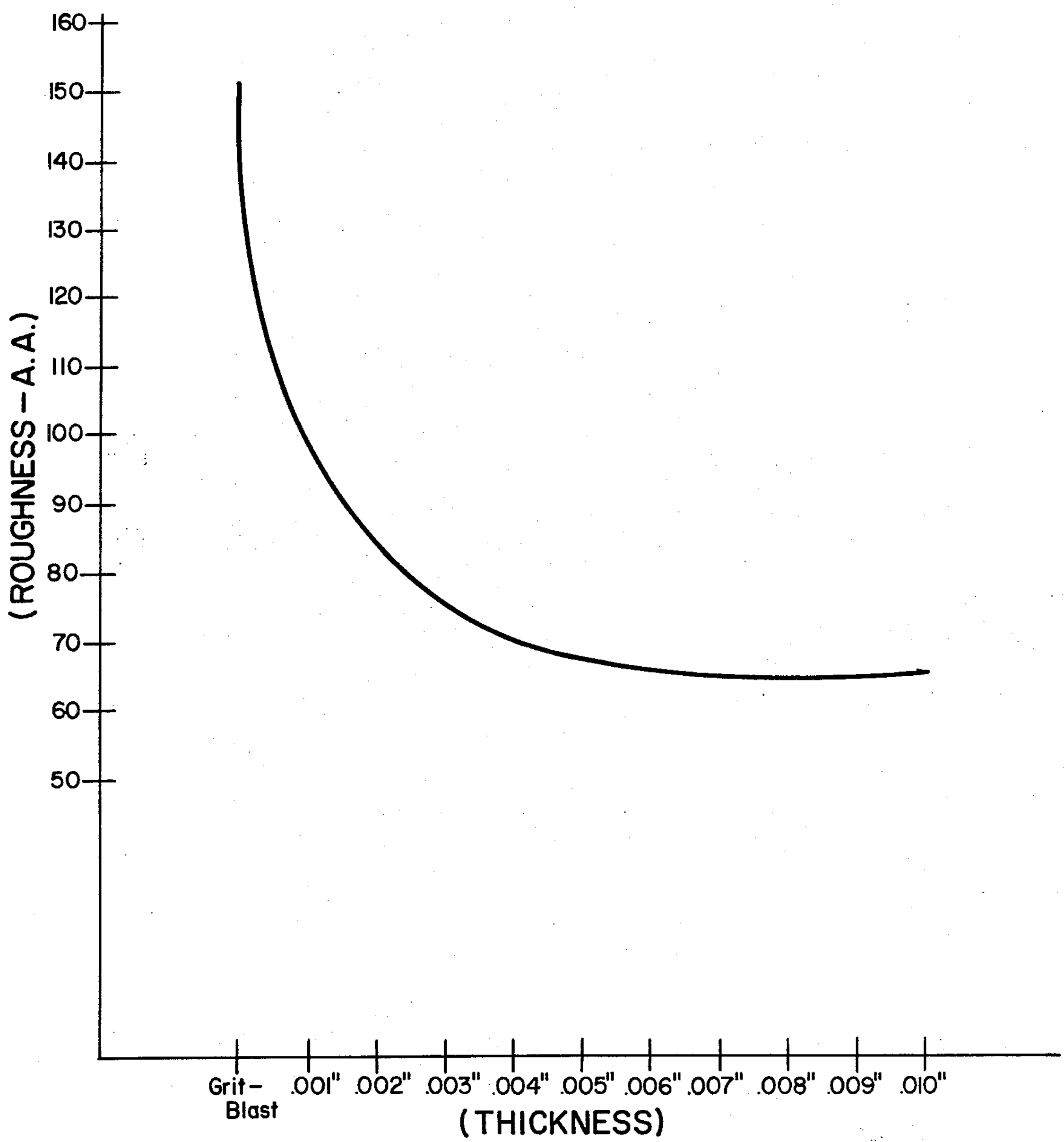

F I G. 3.

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COMPOSITE WEAR RESISTANT MATERIAL AND METHOD OF MAKING SAME

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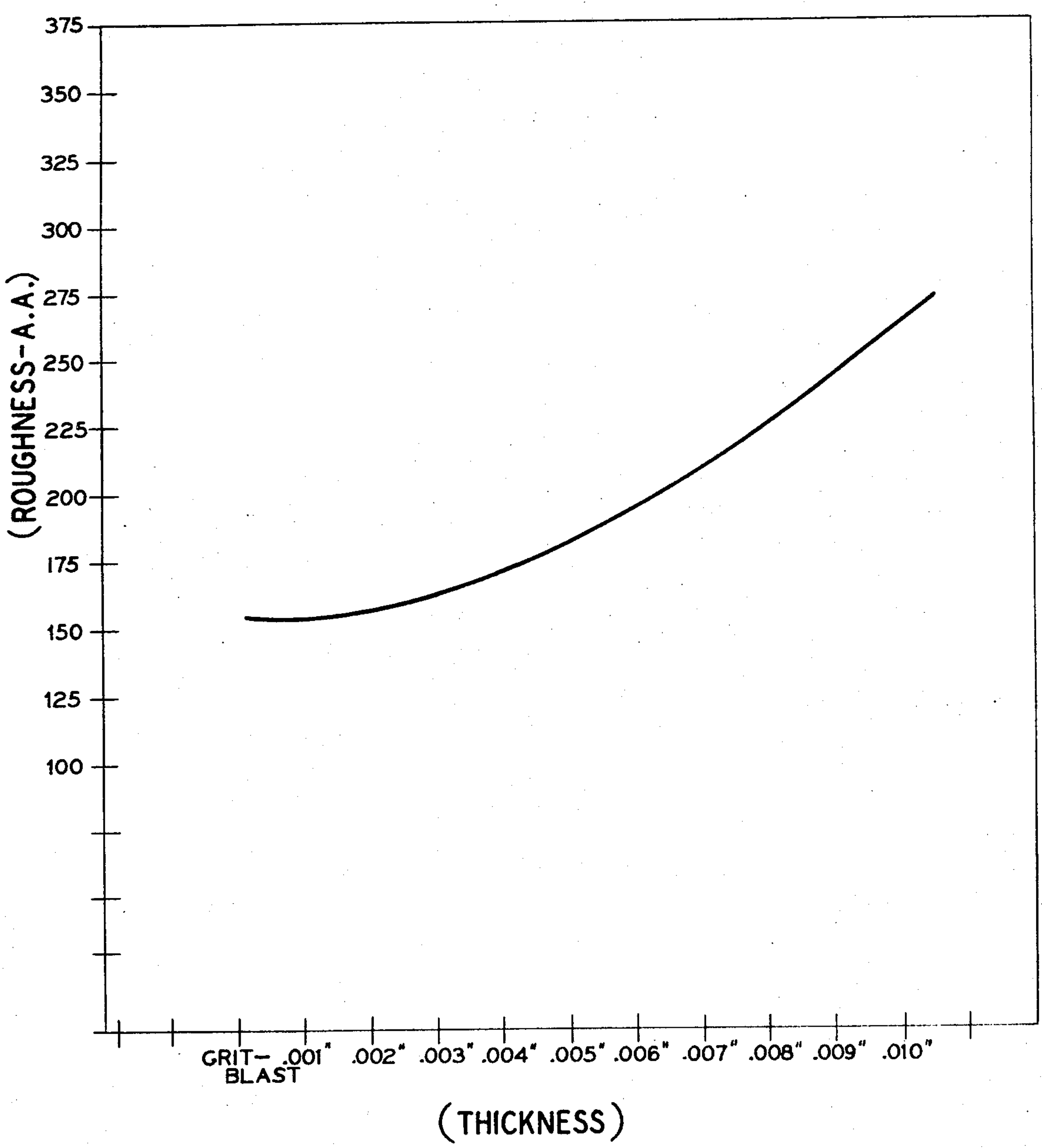

FIG. 4.

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COMPOSITE WEAR RESISTANT MATERIAL AND METHOD OF MAKING SAME

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Continuation-in-part of application Ser. No. 20,582, Mar. 18, 1970. This application Oct. 8, 1970, Ser. No. 79,090
Int. Cl. C23d 5/10
U.S. Cl. 117—93.1 PF 7 Claims

ABSTRACT OF THE DISCLOSURE

A method of forming a metal oxide coating upon a workpiece, which coating may have a closely controlled surface roughness over a wide range of coating thicknesses. The method consists of applying a metal oxide base coating by an arc torch deposition process and thereafter applying a top surface coating of metal oxide with a detonation gun deposition process. A wear-resistant composite coating having an arc torch-applied base portion with a roughness of 100 A.A. to 150 A.A. combined with a detonation gun-applied top surface coating having surface roughness of 150 A.A. to 450 A.A. is also disclosed as a preferred textile surface.

This application is a continuation-in-part of application Ser. No. 20,582, filed Mar. 18, 1970, and now abandoned.

This invention relates to a ceramic coated workpiece and more particularly to ceramic coated workpieces for the textile industry which have closely controlled surface roughness over a wide range of coating thicknesses.

It has heretofore been proposed to coat workpieces with ceramic metal oxide materials such as chrome oxide, aluminum oxide, and the like, for increasing the wear resistance of the workpiece when the same is contacted by a moving textile fiber. In order that the textile fiber pass over the ceramic surface without being damaged, it has been necessary to closely control the roughness of the ceramic surface.

It is often desirable that a ceramic coating have not only a specified surface roughness, but that it have this roughness with a specified coating thickness.

Since it has heretofore been found that with any given process for forming the ceramic coating the surface roughness varies as a function of the thickness of the coating, it has been extremely difficult to meet many specifications requiring certain combinations of roughness and coating thickness, i.e., it has not been possible to control the surface roughness of a ceramic coating independently of its thickness over a substantial thickness range.

One solution to overcoming this difficulty has been to utilize a metal base coating, such as nickel or aluminum, to build up the workpiece to some intermediate thickness followed by applying an arc torch coating of ceramic material on top of the base metal to the desired roughness. This procedure is not only expensive, but also prevents the easy removal of the entire coating to expose the original workpiece, i.e., grinding or turning is necessary to remove the metal undercoat after the top coating has been removed by a grit blast operation.

One object of the invention is to provide a wear-resistant textile fiber compatible ceramic coating which can have a roughness substantially independent of its thickness over a substantial coating thickness range.

Another object is to provide a ceramic coating which is compatible with a textile fiber moving in contact therewith, which coating is also totally removable by grit blasting and without the need for grinding or turning.

Other objects and advantages of the invention will be apparent from the following disclosure and appended claims.

In the drawings:

FIG. 1 is a diagram in the nature of a graph showing the relationship of surface roughness versus coating thickness for an aluminum oxide coating applied to a workpiece with an arc torch of the type disclosed in U.S. Pat. No. 3,016,447;

FIG. 2 is a diagram in the nature of a graph showing surface roughness of an aluminum oxide coating versus coating thickness when the same is applied to a workpiece with a detonation gun as disclosed in U.S. Pat. No. 2,714,563;

FIG. 3 is a graph showing the relationship of surface roughness versus coating thickness for a chrome oxide coating applied to a workpiece with an arc torch of the type disclosed in U.S. Pat. No. 3,016,447; and

FIG. 4 is a graph showing the relationship of surface roughness versus coating thickness for a chrome oxide coating applied to a workpiece with a detonation gun as disclosed in U.S. Pat. No. 2,714,563.

Briefly, this invention is based upon the discovery that a ceramic metal oxide coating when applied with a detonation gun will adhere tenaciously to a previously formed metal oxide coating applied to a workpiece with an arc torch.

It has also been found that the resultant composite ceramic material can be easily removed from the workpiece in a single grit blasting operation.

The surface roughness to thickness variation of a metal oxide coating applied with a detonation gun differs substantially from the same metal oxide coating when applied with an arc torch. A combination of an arc torch-applied base coating having a certain thickness with a top coating applied by the detonation gun to the same or different thickness can be used as an effective process for achieving a desired roughness over a much wider range of coating thicknesses than could be attained by either the arc torch process or the detonation gun process utilized alone.

While the arc torch-applied base coating and the detonation gun-applied top surface coating will usually have the same chemical composition, different metal oxides may also be used if necessary to obtain a desired specification of roughness and coating thickness.

More specifically, a composite wear-resistant ceramic material having a surface compatible to textile fiber may be formed according to the invention. Such material comprises in combination with a workpiece, a metal oxide base coating on the workpiece having a surface roughness of between 70 A.A. and 150 A.A. and a top coating of metal oxide on top of the base coating having a surface roughness of between 150 A.A. and 450 A.A. The composite material is formed with a base coating thickness of .001" to .015", the top coating provided as a thickness of .001" to .010". Preferred metal oxide materials are aluminum oxide and chrome oxide.

The surface roughness terminology and measurements as used throughout the specification and claims are in microinches and the reference "A.A." refers to the arithmetical average of the same.

In practice a workpiece, for example, is one formed of aluminum or steel, which is first chemically cleaned with a suitable degreasing solvent, such as trichloroethylene. Thereafter the workpiece surface to be coated is grit blasted with a dry, free-flowing aluminum oxide blasting grain grit, e.g., #30 to #60 mesh grain size.

The workpiece is next subjected to a continuous stream of aluminum oxide or chrome oxide material which has been electrically arc heated by a high temperature arc torch device which causes the metal oxide material to be formed into a high velocity molten stream. When the molten stream from the arc torch impinges upon the surface of the workpiece a coating having tenacious bond is formed thereon.

The amount of metal oxide deposited by the arc torch is determined by first determining the thickness of the detonation gun-applied metal oxide coating which corresponds with the surface roughness required. Thereafter the thickness of coating to be applied by the arc torch is determined by subtracting from the total thickness of coating desired, the thickness of the detonation gun-applied coating necessary to attain the required roughness.

The invention will now be illustrated by referring to the following examples.

EXAMPLE NO. 1

It is desired to form aluminum oxide coating having a surface roughness of 150 A.A. to 250 A.A. and a thickness of .0075". As shown in FIG. 1, the roughness of a .0075" thick arc torch-applied coating would be approximately 125 A.A., which is substantially less than required.

Referring to FIG. 2, a .0075" thick detonation gun-applied coating would have a roughness of about 350 A.A., which is substantially higher than the roughness required. According to the invention, a roughness of 200 A.A. (the midpoint between the 150 A.A. and 250 A.A. required) of a detonation gun-applied coating would correspond with a coating thickness of about .003". Since the total coating thickness in this instance is .0075", the amount of base coating to be applied with an arc torch will be about .0075" minus .003" or .0045".

EXAMPLE NO. 2

It is desired to form an aluminum oxide coating having a surface roughness of 250 A.A. to 350 A.A. and a coating thickness of .015". As shown in FIG. 1, an arc torch-applied aluminum oxide coating will not offer sufficient roughness to meet the required specification. As shown in FIG. 2, however, a detonation gun-applied aluminum oxide coating having a surface roughness of 300 A.A. (the middle between 250 A.A. and 350 A.A.) corresponds with a coating thickness of .006". In order to meet the surface roughness and thickness specification an arc torch-formed base coating of aluminum oxide is applied to a thickness of .015" minus .006". The top coating of aluminum oxide formed with a detonation gun is thereafter applied on top of the base coating to a thickness of .006" to meet the specified surface roughness.

It will be appreciated from the foregoing that, given the desired thickness and roughness characteristics, one may refer to FIGS. 3 and 4 and readily determine the particular thickness of arc torch-deposited base coating to be

employed to provide a top coating detonation gun-deposited material with the given roughness and over-all thickness as specified. Graphs for other metal oxides may also be made up and similarly utilized.

What is claimed is:

1. A method of forming a duplex metal oxide ceramic coating upon a workpiece, said coating having a surface roughness substantially independent of its thickness over a substantial coating thickness range, which method comprises:

(a) spraying an electrically arc-heated continuous stream of metal oxide material onto the surface of the workpiece to form a base coating thereon and thereafter,

(b) spraying by detonation gun means a pulsed high-velocity stream of molten metal oxide particles on top of said base coating to form a top coating thereon.

2. The method of claim **1**, wherein said metal oxide is in each instance aluminum oxide.

3. The method of claim **1**, wherein said metal oxide is in each instance chrome oxide.

4. A method as claimed in claim **1**, wherein step (a) is continued until a base coating having a thickness of 0.001 inch to 0.015 inch is formed and thereafter step (b) is continued until said top coating has a thickness of 0.001 inch to 0.010 inch.

5. A composite wear resistant material comprising a workpiece having on its surface a metal oxide base coating between 0.001 inch and 0.015 inch thick with a surface roughness between 70 A.A. and 150 A.A., and a top coating of a metal oxide on top of said base coating between 0.001 and 0.010 inch thick with a surface roughness of between 150 A.A. and 450 A.A.

6. The composite material of claim **5** wherein said base coating is aluminum oxide having a surface roughness between 100 A.A. and 150 A.A., and wherein said top coating is aluminum oxide having a surface roughness of between 150 A.A. and 450 A.A.

7. The composite material as in claim **5** wherein said base coating is chrome oxide having a surface roughness of between 70 A.A. and 150 A.A., and wherein said top coating is chrome oxide having a surface roughness of between 150 A.A. and 275 A.A.

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U.S. Cl. X.R.

117—105.2, 129