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SINTERED RUBBING CONTACT MATERIAL AND METHOD
FOR PRODUCING SAME
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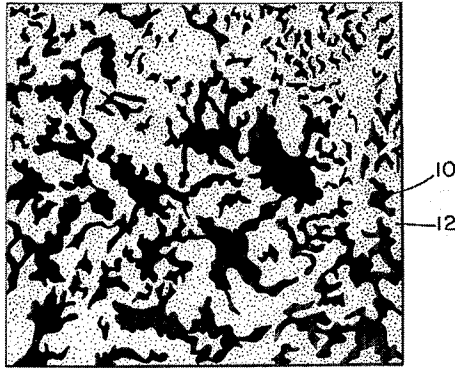


FIG. 1

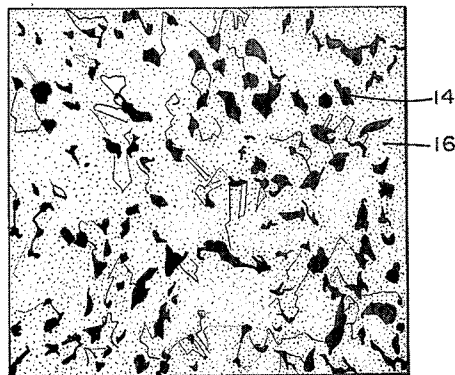


FIG. 2

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1

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SINTERED RUBBING CONTACT MATERIAL AND METHOD FOR PRODUCING SAME

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This invention relates to a sintered rubbing material and to the method for producing same and, more particularly, to an improvement of a novel rubbing material disclosed in copending application U.S. Serial No. 26,751, now U.S. Patent No. 3,081,196, Robert J. MacDonald, assigned to the same assignee as this application. The material may be used for bearings, piston rings, seals, clutch plates and the like.

The above noted application pertains to material formed by a matrix of a metal powder mixture consisting, generally, of a material whose free energy of oxide formation is more positive than lead oxide, e.g., copper or silver, and in which the matrix is infiltrated by particles predominantly of lead oxide. It was noted in the said application that a comparatively large amount of predominantly lead oxide particles, combined with other oxides, are infiltrated into the matrix, to provide at the rubbing surfaces of the mating materials always a rather substantial amount of the predominantly lead oxide base particles. By virtue of the depth of the matrix material, the rubbing surface material withstands wear over a long period of time and still functions to provide bearing material at the mating surfaces.

This invention avoids infiltration of the matrix by the lead oxide base materials and thereby overcomes some of the problems inherently connected with this approach. While an infiltrated matrix of a composite material here under consideration may be desirable, under certain conditions and for some applications, there are, nevertheless, others in which an infiltrated structure has distinct disadvantages.

Infiltration is a function of the viscosity of the material, in this case molten oxide, a high viscosity melt, will not always suitably infiltrate the matrix material. Moreover, the binary lead oxide mixture has a certain range of viscosity which depends upon the alloying addition. Thus, only certain mixtures readily infiltrate. Furthermore, infiltration is at times difficult to control especially when the rate of infiltration is rather slow. Inasmuch as molten lead oxide readily dissolves copper, a prolonged surface contact can result in appreciable surface erosion and structural weakening. An infiltrated structure must by its very nature have inter-connecting areas of such lead oxide particles which have a deleterious effect on the machinability of the composite material. This is to say, that large inter-connecting areas of lead oxide or alloys thereof are, under certain circumstances, readily pulled out by a machine tool, leaving voids of at least microscopic dimensions in the finished surface.

It has now been recognized that these conditions can be overcome by solidly sintering a blended mixture of the matrix material and the powder particles predominantly of lead oxide. In this improved article the powder particles of predominantly lead oxide form independent and discontinuous lakes which are embedded in the matrix material.

2

It is therefore an object of this invention to provide an article of the type here under consideration which has improved metallurgical characteristics and establishes greater physical contact between the individual metal powder particles.

It is another object of this invention to provide a unique method for producing the improved articles.

It is another object of this invention to provide a material and a method for producing such material in which the dispersion of the lead oxide or alloys thereof in the material is substantially improved so as to avoid pulling these particles out during the machining operation.

It is a still further object of this invention to provide a material and a method for producing same which is more compatible with the unique requirements of viscous oxide whereby a greater variety of lead oxide mixtures may be sintered with the matrix material than is normally possible with the infiltration approach previously discussed.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

An aspect of the present invention resides in a method of forming a sintered powder metal member which includes the steps of blending powder particles selected from a group consisting of copper, silver and alloys thereof with powder particles consisting essentially of lead oxide, to establish a uniformly distributed mixture. Thereafter the mixture of powder particles is compacted to green density and then the compacted mixture is sintered to metallurgically bond the individual powder particles together.

Another aspect of the present invention resides in the provision of a method of providing a sintered powder metal lining upon a solid reinforcing metal back which comprises the steps of depositing an intermediate layer of bonding material upon a substantially flat surface of a continuous strip of non-porous metal. Then there are blended powder particles of a material whose free energy of oxide formation is more positive than lead oxide with powder particles predominantly of lead oxide and the resulting mixture is spread upon the flat surface of the strip facing the intermediate layer. Thereafter, the strip is passed through a sintering chamber which has conditions effective to sinter the powder particles together for establishing merely a point contact between the particles and, moreover, to metallurgically bond the particles to the flat surface of the strip. The strip is then passed through a pair of pressure rolls to establish a predetermined density of the metal lining; the strip is then passed through a chamber which has conditions therein effective to re-sinter the powder particles together at their contacting surfaces.

A further aspect of the invention resides in the provision of a sintered powder metal member formed from a metal powder mixture of a matrix material whose free energy of oxide formation is more positive than lead oxide and powder particles predominantly of lead oxide, and in which the powder particles of predominantly lead oxide form independent and discontinuous lakes in the matrix material.

A further aspect of this invention resides in the provision of a composite metal member which comprises a steel backing member and an intermediate bonding layer co-extensively bonded to the backing member and wherein the bonding layer consists of a metal taken from the group of metals whose free energy of oxide formation is more positive than lead oxide and alloys thereof. The composite metal member also includes a solidly sintered bearing layer which is coextensively bonded to and overlays the intermediate layer and is formed of a metal powder mixture of a matrix material whose free energy of oxide formation is more positive than lead oxide and in which the powder particles of predominantly lead oxide form independent and discontinuous lakes which are embedded in the matrix material.

FIGURE 1 is a drawing made from a photo-micrograph, magnified 250 times, showing the metallurgical characteristics of the material of the above-named co-pending application for comparative purposes only. The reference numeral 10 designates the generally continuous lakes of the lead oxide base material. Where such continuity is not visible, the continuity exists in another plane. The light areas 12 in the FIGURE 1 represents the matrix material and of course includes such voids.

FIGURE 2 is a drawing made from a photo-micrograph showing, magnified 250 times, the metallurgical characteristics of the material of the present invention. There is shown in the drawing independent and discontinuous lakes of the lead oxide base material 14 which are embedded in the matrix 16.

An essential quality for the matrix material is that the metal powders forming such matrix have a free energy of oxide formation which is more positive than that of lead oxide so that the matrix material does not tend to reduce the lead oxide to metallic lead when both of the materials are co-sintered. Both copper and silver satisfy this requirement. Moreover, silver can also be used as an alloying element to strengthen the copper without adverse effect to the lead oxide. Arsenic may be used as an alloying element, too, however it is not satisfactory as a base metal.

In the following discussion, the terms "copper" and "lead oxide" are consistently used for purposes of illustrating the invention. The extent to which other materials can be substituted for, or combined with, these materials has been delineated in other parts of this specification. In no event, however, should the sole reference to copper and to lead oxide be interpreted in a restrictive sense.

Almost any grade of copper powder is acceptable. However, one powder blend has been found to be particularly well suited because when mixed with fine powder oxides it flows very readily. This is an important property, especially for use with high speed compacting presses commonly employed in the powder metal industry. The nominal screen analysis of this preferred copper blend is as follows:

Nominal percent:	Screen size
8 -----	-100+150
22 -----	-150+200
9 -----	-200+250
23 -----	-250+325
38 -----	-325

Composites have been made with additions of lead oxide per se, as well as with lead oxide base mixtures. The strength of the composite material is primarily attributed to the copper matrix, whereas the oxide additions provide friction wear qualities.

Following is Table I which gives a large number of lead oxide base mixtures and some pertinent information relating thereto which fall within the scope of the present invention. At the head of Table I is reference data for lead which are included for purposes of comparison.

Table I

PbO-BASE MIXTURES

Additive	Range, percent	Eutectic specific example, percent	Melting T., degrees F.	Melt condition
PbO-----	Min. 51-----		1,630	Viscous.
10 SiO ₂ -----	Balance-----	{ 8 15 23	1,350 1,350 1,350	Fluid. Viscous. Very Viscous.
Al ₂ O ₃ -----	do-----	{ 4 28	1,589 1,075	Do. Fluid.
Bi ₂ O ₃ -----	do-----	{ 28 8	1,075 1,445	Fluid. Viscous.
PbO-CrO ₃ -----	do-----	{ 8 13	1,445 1,400	Fluid. Fluid.
V ₂ O ₅ -----	do-----	{ 45 5	900 1,475	Viscous. Fluid.
15 As ₂ O ₃ -----	do-----	{ 17 33	1,500 1,450	Do. Do.
PbO-MoO ₃ -----	do-----	{ 18 29	1,450 1,335	Do. Do.
PbO-WO ₃ -----	do-----	{ 29 (Phase Diagram Incomplete)	1,335	Do.
Sb ₂ O ₃ -----	do-----	{ 12 3	925 1,500	Do. Do.
20 B ₂ O ₃ -----	do-----	{ 3 1.5	925 1,570	Do. Very Viscous.
TiO ₂ -----	do-----	{ 5 9	1,500 1,550	Fluid. Do.
SnO ₂ -----	do-----	{ 25 18	1,500 1,260	Do. Very Viscous.
P ₂ O ₅ -----	do-----	{ 25 18	1,500 1,260	Do. Very Viscous.
5 Cu ₂ O-----	do-----	{ 18 18	1,260	Very Viscous.
Fe ₃ O ₄ -----	do-----	{ 18 18	1,260	Very Viscous.

A proper balance must be obtained to produce a rubbing material having the best combination of rubbing qualities and mechanical strength. With a copper matrix, it is believed that the addition of 5 weight percent of a lead oxide base mixture, such as for instance PbO-8SiO₂, will provide a substantial improvement in rubbing characteristics compared to unalloyed copper. Above 20 weight percent of oxide the strength of the composite material and also the wear resistance during rubbing are reduced.

The best oxide range for most applications appears to be in the area between 10 and 15 weight percent. The composite metal body is densified to a degree considerably short of the theoretical density so that the body may be impregnated with a lubricant to provide a self-lubricating rubbing member if such properties are desirable. It has been found that a 10% porosity in a compacted matrix permits retention of some oil and allows some degree of conformability within the material.

The process for fabricating the above-described composite material into a compact and sintered member is described in two parts. The first part relates to solid sintered composite structure per se, while the second part is concerned with a metal lining formed of this composite material and bonded to a steel backing member. Fundamental to both methods is the sintering of the composite matrix material in the presence of lead oxide and/or alloys thereof. This factor is of paramount importance.

In the process for the composite structure per se, the matrix materials are first thoroughly blended with a lubricant to coat the copper particles to reduce the frictional forces which develop between the particles and the die wall during the pressing operation. It is entirely possible, however, to press these powders without the addition of a lubricant. But, to prolong tool life and to permit a faster rate of pressing, it is desirable that a lubricant be added to the blend. It has been found best to blend the copper particles with stearic acid for one-quarter hour before adding the oxide base mixture at which time the blending is continued for an additional three-quarters hour. By blending first the copper particles and the lubricant, the lubricant has a better chance to coat the copper powder and the tendency for oxide lubricant balling is greatly reduced.

The blended mixture is then compacted by conventional automatic pressing devices. The green density to which the materials are pressed is of some importance. I have found a green density of 7.3 g./cc. to be the best. This corresponds roughly to about 83% of the theoretical density of the composite material. Densities in excess of 7.3 g./cc. have the tendency to cause the oxide to bleed

during the sintering process. This occurs because the oxides melt and expand, and if this expansion cannot be taken up by internal porosity, the oxide will exude out of the compact. To achieve such a green density a compacting pressure in the vicinity of 50,000 p.s.i. is required.

The compacted mixture of the powder particles is then sintered in a two-stage process.

The first step in the two-step sintering process constitutes a pre-oxidation treatment to provide a film of cupric oxide around the copper particles. Generally, this treatment is effected at a temperature between 700° and 1000° F. A preferred temperature is 800° F. which appears to provide a controlled oxidation without prolonged temperature exposure. Depending on the mass of the piece treated, times on the order of 10 to 15 minutes are used at this temperature. At higher temperatures, of course, it is possible to reduce the time element, however, temperatures substantially above 800° F. cause cuprous oxide (Cu_2O) to be formed. This coating, however, is not as tenacious as cupric oxide (CuO) and in some cases easily spalls from the copper. This preoxidation treatment prior to sintering is desirable for two primary reasons: (1) it eliminates the free lead formed by the decomposition of the powdered lubricant and (2) provides a surface structure having optimum rubbing characteristics.

With the addition of Cu_2O , the melting point of PbO is thereby lowered from 1630° F. to 1260° F. It appears that a similar relationship must also exist for the PbO-CuO system. When a film of CuO is present on each copper particle, sintering above 1260° F. results in a wetting of all copper surfaces with PbO , or when previously alloyed, a PbO rich mixture. Such a behavior allows the oxide to be at the immediate surfaces of the part after sintering. Therefore, subsequent coining or sizing can make the part entirely usable without the need for machining.

The presence of a film of CuO also serves another function during the sintering process. Any metallic lead which forms due to the burning off of the powdered lubricant will react when molten with CuO and will cause a Thermit reduction producing metallic Cu and PbO . In this way, the presence of Pb may be almost completely eliminated from the composite.

It is implicit in the above statement that the preoxidation treatment is not a strict requirement for producing a composite of Cu and PbO . However, to permit fabrication by conventional powder metal means, and to produce an end material having optimum strength and rubbing properties, this pre-treatment offers considerable advantages.

The preoxidized compact is then sintered to strengthen the bonding between the copper particles and to obtain a bond between the PbO or PbO base mixtures and the copper particles. While the temperature required for sintering is not critical it has been found best to sinter above the melting point of the oxide addition. A temperature range of 1400° to 1700° F. generally applies to the compositions of this invention. Thus, for PbO which melts at 1630° F., sintering may be accomplished between 1650° and 1750° F. On the other hand, for example, the PbO-8SiO_2 binary alloy, which melts between 1250° and 1350° F. sintering can be accomplished at 1500° to 1550° F. The preferred holding time at the sintering temperature to obtain reproducible strength property appears to be at around 15 minutes, although this aspect is not too critical. Because PbO is readily reduced to metallic Pb , sintering cannot be done using a reducing atmosphere, such as hydrogen, endothermic, exothermic, or dissociated ammonia gases without post oxidation as noted below. An inert gas such as argon or nitrogen is used. While normally the sintering of unalloyed copper in an inert atmosphere is not nearly as effective as when a reducing gas is used, it should be noted that this difficulty is overcome by the addition of PbO and its alloys to Cu powder inasmuch as,

during sintering, some PbO will vaporize and actually combine with any CuO or Cu_2O present, leaving a clean copper surface. Alternatively, the lead particles may be post oxidized to convert these particles to lead oxide by Thermit reaction with the copper oxide particles.

Upon sintering the material or post oxidation as aforesaid, it is desirable to repress or coin the compact. This may be done using the same tooling equipment used for compacting the original green compact since the sintering process results in very little dimensional change. Normally, the same amount of pressure applied during the compacting step may also be used for coining the sintered compact. The specified density of the final composite will depend upon the application to which the article will be employed. Where hydrodynamic lubrication conditions exist and where a thin film of lubricant must be maintained, a material near full density is desired. A composite having about 90% density with respect to theoretical density (7.93 g./cc.) appears to be best for such conditions. The 10% porosity remaining in this material allows the retention of some oil. The composite material, more particularly the porous portions thereof, are infiltrated with the lubricant by means of conventional vacuum impregnation methods. It is obvious, where the final density is decreased, the internal oil supply may be raised which makes it possible to provide a self-lubricating composite material.

The method of providing a sintered powder metal lining upon a solid reinforcing metal back, follows, generally, the basic concept of the invention outlined above. To facilitate the bonding of the composite material to the steel backing member and to eliminate any undesirable reaction between PbO or PbO base mixtures and the steel backing member, the latter is plated with a bonding material that has the same characteristic with respect to the oxide formation as above described. Thus, generally, the steel member is plated with a copper or silver overlay or an alloy thereof; a copper film within the range of .0005 to .002 inch is sufficient for most of the compositions above named. Greater thicknesses, however, may be necessary where materials of higher melting temperatures are utilized.

The powder blends of copper and oxide are prepared following the procedure outlined above. No lubricant is added since the process steps necessitating such lubrication are absent. The blended powder mixture is then spread upon the flat surface of the strip facing the intermediate layer. The strip is then passed through a sintering chamber which has conditions therein to sinter the powder particles together to establish a point contact, i.e., limited cohesion, between the particles and to metallurgically bond the particles to the flat surface of the strip. The temperature for sintering the strip should normally be between 1400° and 1700° F. for the various compositions discussed herein. For example for a Cu-PbO-SiO_2 blend, a temperature of about 1500° F. appears to be best suited.

Ordinarily in the fabrication of steel backed bearings of, for instance, copper lead, babbitt, or aluminum material, final sizing is accomplished by precision boring. Thus, the surface condition of the cast or sintered strip is not important. In some cases, however, it may be desirable to form a bearing from a strip stock and to prepare the final bore by sizing or roller burnishing techniques. In such an instance, it is desirable to have a surface with optimum oxide distribution. For this reason the free-sintered composite may be preoxidized, a treatment comparable to that employed in the aforescribed method. It should be noted that this preoxidizing should, preferably, take place before the rolling step.

The free sintered strip is now rolled to at least a 75% reduction to densify and to increase its bond strength. The preferred range for densifying the sintered powder mixture is between 80% and 95% of theoretical density. The strip is then re-sintered at a temperature between

1400° and 1700° F. to sinter and fuse the contacts of the particles together to strength and improve the bond. Upon re-sintering the strip the powder mixture may then be vacuum impregnated with a lubricant which fills the remaining pores. The finished strip is then machined or finished by conventional methods to the desirable finish and end structure.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is aimed, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with powder particles consisting essentially of lead oxide to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; and sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together.

2. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with a lubricant for applying a protective coat onto said particles; blending the coated particles with powder particles consisting of a lead oxide mixture to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; and sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together.

3. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with powder particles consisting essentially of lead oxide to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; preoxidizing the compacted mixture by subjecting the mixture to a temperature effective to oxidize the particles selected from the said group of copper, silver and alloys thereof; and then sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together.

4. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with powder particles consisting essentially of lead oxide to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together; and thereafter oxidizing the sintered and compacted mixture by exposing the mixture to an oxidizing gas to re-oxidize by thermit reaction those lead oxide particles which have been reduced to lead.

5. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with powder particles consisting essentially of lead oxide to establish a uniformly distributed mixture;

compacting said mixture of powder particles to green density; sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together; and then coining the sintered and compacted mixture to final size, shape and density.

6. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending copper particles, whose free energy of oxide formation is more positive than lead oxide, with particles consisting essentially of lead oxide to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; pre-oxidizing the compacted mixture to provide a film of cupric oxide around said copper particles by subjecting the mixture to a temperature of 700° to 1000° F.; and sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together.

7. The method of forming a sintered powder metal member for rubbing contact including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with powder particles of lead oxide and additives selected from a group consisting of: SiO_2 , Al_2O_3 , Bi_2O_3 , CrO_3 , V_2O_5 , As_2O_5 , MoO_3 , WO_3 , Sb_2O_3 , B_2O_3 , TiO_2 , SnO_2 , P_2O_5 , Fe_3O_4 , and Cu_2O ; compacting said mixture of powder particles to green density; and sintering the compacted mixture in an inert atmosphere by subjecting the mixture to a temperature above the melting point of the lead oxide when singularly present, and above the melting point of the lead oxide base mixture when said lead oxide is combined with one or more of said additives, to metallurgically bond the powder particles together.

8. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver and alloys thereof with a lubricant for applying a protective coat onto said particles; blending the coated particles with powder particles consisting essentially of lead oxide to establish a uniformly distributed mixture; compacting said mixture of powder particles to green density; pre-oxidizing the compacted mixture by subjecting the mixture to a temperature effective to oxidize the particles of copper, silver and the said alloys thereof; and then sintering the compacted mixture in an inert atmosphere to metallurgically bond the individual powder particles together.

9. The method of forming a sintered powder metal member for rubbing contact, including the steps of: blending powder particles selected from a group of materials whose free energy of oxide formation is more positive than lead oxide and consisting of copper, silver, and alloys thereof with a lubricant for applying a protective coat onto said particles; blending the coated particles with powder particles of lead oxide and additives selected from a group consisting of SiO_2 , Al_2O_3 , Bi_2O_3 , CrO_3 , V_2O_5 , As_2O_5 , MoO_3 , WO_3 , Sb_2O_3 , B_2O_3 , TiO_2 , SnO_2 , P_2O_5 , Fe_3O_4 , and Cu_2O ; compacting said mixture of powder particles to green density; pre-oxidizing the compacted mixture by subjecting the mixture to a temperature effective to oxidize the particles of copper, silver and the said alloys thereof; and thereafter sintering the compacted mixture in an inert atmosphere by subjecting the mixture to a temperature above the melting point of the lead oxide when singularly present, and above the melting point of the lead oxide base mixture when said lead oxide is combined with one or more of the additives, to metallurgically bond the individual powder particles together.

10. The method of providing a sintered powder metal lining for rubbing contact upon a solid reinforcing metal back, including the steps of: depositing an intermediate

layer of bonding material upon a substantially flat surface of a continuous strip of nonporous metal; blending powder particles of a material whose free energy of oxide formation is more positive than lead oxide with powder particles predominantly of lead oxide and spreading the resulting mixture upon the flat surface of said strip facing said intermediate layer; then subsequently passing said strip through a sintering chamber having conditions therein effective to sinter said powder particles together for establishing merely a point contact between said particles and to metallurgically bond said particles to said flat surface of said strip; thereafter passing said strip through a pair of pressure rolls to establish a predetermined density of the metal lining; and then subsequently passing said strip through a chamber having conditions therein effective to re-sinter the powder particles together at their contacting surfaces.

11. The method according to claim 10 wherein the strip is passed through said rolls to densify said compacted powder particle between 80 and 95 percent of theoretical density.

12. The method of providing a sintered powder metal lining for rubbing contact upon a solid reinforcing metal back, including the steps of: depositing an intermediate layer of bonding material upon a substantially flat surface of a continuous strip of nonporous metal; spreading a loose layer of a copper powder base mixture composed of material whose free energy of oxide formation is more positive than lead oxide, including particles of lead oxide, upon the flat surface of said strip facing said intermediate layer; then subsequently passing said strip through a sintering chamber having an inert atmosphere and a sintering temperature above the melting point of lead oxide to sinter said powder particles together establishing a point contact between said particles and to metallurgically bond said particles to said flat surface of said strip; thereafter passing said strip through a pair of pressure rolls to establish a predetermined density of the metal lining; and then subsequently passing said strip through a chamber having conditions therein effective to re-sinter the powder particles together at their contacting surfaces.

13. The method of providing a sintered powder metal lining for rubbing contact upon a solid reinforcing metal back, including the steps of: depositing an intermediate layer of bonding material upon a substantially flat surface of a continuous strip of nonporous metal; spreading a loose layer of a copper powder base mixture composed of material whose free energy of oxide formation is more positive than lead oxide, including in a minor amount powder particles of a lead oxide base eutectic mixture, upon the flat surface of said strip facing said intermediate layer; then subsequently passing said strip through a sintering chamber having a sintering temperature above the melting point of the lead oxide base eutectic mixture to sinter said powder particles together establishing a point contact between said particles and to metallurgically bond said particles to said flat surface of said strip; then subsequently passing said strip through a pair of pressure rolls to establish a predetermined density of the metal lining; and then subsequently passing said strip through a sintering chamber having a sintering temperature above the melting point of the eutectic mixture to re-sinter the powder particles together at their contacting surfaces.

14. The method according to claim 13, in which the eutectic mixture is composed of PbO-SiO_2 and the temperature applied for sintering said mixture is between 1400° and 1700° F.

15. The method according to claim 13, in which the powder particles are sintered in a non-oxidizing atmosphere.

16. The method of providing a sintered powder metal lining for rubbing contact upon a solid reinforcing metal back, including the steps of: depositing an intermediate layer of bonding material upon a substantially flat sur-

face of a continuous strip of non-porous metal; blending a copper powder base mixture, whose free energy of oxide formation is more positive than lead oxide, with powder particles predominantly of lead oxide and spreading the resulting mixture upon the flat surface of said strip facing said intermediate layer; then subsequently passing said strip through a sintering chamber having conditions therein to sinter said powder particles together establishing a point contact between said particles and to metallurgically bond said particles to said flat surface of said strip; pre-oxidizing the point contact sintered mixture by subjecting the mixture of particles to a temperature effective to oxidize the particles composed of said copper base mixture to establish a film of cupric oxide around the particles; then subsequently passing said strip through a pair of pressure rolls to establish a predetermined density of the metal lining; and thereafter passing said strip through a chamber having an inert atmosphere and conditions therein to re-sinter the powder particles together at their contacting surfaces.

17. The method according to claim 16, wherein said mixture is pre-oxidized at a temperature between 700° and 1000° F.

18. The method according to claim 13, wherein the metal lining of said strip while passing through said rolls is densified to a degree short of theoretical density, and then, subsequent to the re-sintering step filling the remaining pores with a lubricant through vacuum impregnation.

19. A sintered rubbing contact member formed from a metal powder mixture of a matrix material whose free energy of oxide formation is more positive than lead oxide and powder particles predominantly of lead oxide, said powder particles of predominantly lead oxide forming independent and discontinuous lakes embedded in said matrix material.

20. A rubbing contact member substantially as in claim 19, further characterized by said matrix material consisting essentially of copper.

21. A rubbing contact member substantially as in claim 19, further characterized by said matrix material consisting essentially of silver.

22. A rubbing contact member substantially as in claim 19, further characterized in that said powder particles predominantly of lead oxide include at least one other oxide material.

23. A rubbing contact member substantially as in claim 22, further characterized in that the last mentioned other oxide material is selected from a group consisting of SiO_2 , Al_2O_3 , Bi_2O_3 , CrO_3 , V_2O_5 , As_2O_5 , MoO_3 , WO_3 , Sb_2O_3 , B_2O_3 , TiO_2 , SnO_2 , P_2O_5 , Fe_3O_4 , and Cu_2O .

24. A sintered rubbing contact member formed from a metal powder mixture of a copper powder matrix material and powder particles predominantly of lead oxide; the said particles of lead oxide constituting at least five weight percent, but not substantially more than twenty weight percent, of the total powder mixture, and said lead oxide particles forming independent and discontinuous lakes embedded in said matrix material.

25. A rubbing contact member substantially as in claim 24, further characterized in that the composite mixture has a density of at least 75% of the theoretical density providing a porous structure; and an infiltrating lubricant within said pores.

26. A composite rubbing contact member comprising: a steel backing member; an intermediate bonding layer coextensively bonded thereto wherein said layer consists of a metal taken from the group of metals whose free energy of oxide formation is more positive than lead oxide and alloys thereof; and a solidly sintered bearing layer coextensively bonded to and overlaying said intermediate layer and formed of a metal powder mixture of a matrix material whose free energy of oxide formation is more positive than lead oxide and powder particles predominantly of lead oxide, said powder particles of

predominantly lead oxide forming independent and discontinuous lakes embedded in said matrix material.

27. A composite rubbing contact member according to claim 26, further characterized in that the intermediate bonding layer is composed of a material in which copper predominates on a per weight basis.

28. A composite rubbing contact member according to claim 26, further characterized in that the intermediate bonding layer is composed of a material in which silver predominates on a per weight basis.

29. A composite rubbing contact member according to claim 27, further characterized in that the intermediate layer has a thickness between .0005 and .002 inch.

30. A sintered rubbing contact member formed from a metal powder mixture of a matrix material whose free energy of oxide formation is more positive than lead oxide and powder particles of a lead oxide base mixture,

said powder particles of said lead oxide base mixture forming independent and discontinuous lakes embedded in said matrix material.

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