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METHOD OF MAKING POROUS METAL BODIES

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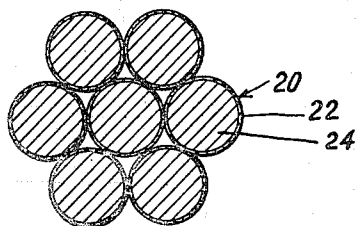


*Fig. 1*

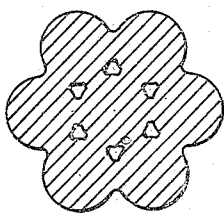


*Fig. 2*

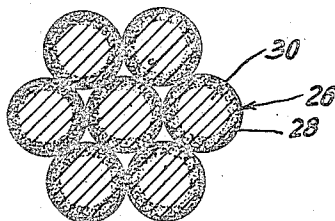


*Fig. 3*

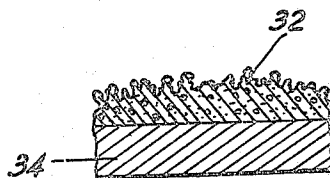


*Fig. 5.*

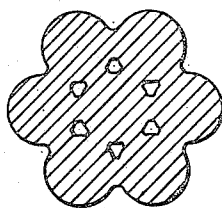


*Fig. 4*

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## UNITED STATES PATENT OFFICE

2,273,589

## METHOD OF MAKING POROUS METAL BODIES

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18 Claims. (Cl. 29—189)

This invention relates to a method of sintering metal powders and is particularly concerned with the sintering of metal powders having a constituent rich surface thereon.

It is an object of the invention to provide a method for making highly porous metal articles capable of permitting fluid flow therethrough, wherein the porosity of the articles may be closely controlled and wherein the shrinkage during sintering may be substantially eliminated.

Another object of the invention is to provide a method for making porous metal objects wherein a porous alloy article is produced from powders having a constituent-rich surface thereon.

In carrying out the above object it is a further object to provide powders which contain at least two constituent metals, one of said metals being rich on the surface of the other metal, that is, each metal powder particle will contain a core of one metal and have a surface rich in another metal. It is a still further object in some cases in carrying out this object to mechanically attach highly comminuted particles of a low melting constituent metal to the surface of larger particles of a higher melting constituent metal.

A further object in some cases is to use powders wherein the constituent rich surface is pre-alloyed to a core or nucleus of another metal whereby the relative positions of the constituents are fixed before sintering in definite positions with one another.

Another object of the invention is to provide porous metal articles having a substantially uniform degree of porosity wherein the strength of the article is relatively high and wherein the finished article may be a homogeneous alloy throughout if desired.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred embodiment of the present invention is clearly shown.

In the drawing:

Fig. 1 is an illustrative view showing highly magnified particles of metal powders 20 having a low melting constituent metal 22 mechanically held to the surface of the high melting constituent 22 prior to the sintering thereof.

Fig. 2 is a view showing the particles as shown in Fig. 1 after sintering thereof.

Fig. 3 is a view of particles of metal powder having a constituent rich surface that have been pre-alloyed prior to sintering.

Fig. 4 is a view of particles in Fig. 3 after sintering the metal thereof.

Fig. 5 is a fragmentary sectional view showing a highly porous metal layer 32 bonded to a steel supporting surface 34.

The use of non-compacted metal powders as mentioned hereinafter is disclosed in Patent No. 2,157,596 and in Patent Nos. 2,198,253, 2,198,702 and copending application Serial No. 253,596, while the use of briquetted materials is shown in the Williams Patent No. 1,556,658, all of which are assigned to the assignee of the present invention.

The present invention is directed to a method whereby the porosity of an alloy article may be closely controlled, the strength increased and the alloying action of the constituent metals to form a more homogeneous article accomplished in a shorter time. In the present invention I propose to attach a low melting constituent metal directly to the surface of a high melting constituent metal whereby the distribution of the constituents are substantially uniform throughout the unsintered article, thereby preventing excessive shrinkage and simultaneously providing for uniform and rapid alloying. It is further apparent that the porosity of the finished article will be substantially uniform and may be closely controlled.

The attachment of the low melting constituent metal to the higher melting constituent metal may be accomplished in several manners, for example, copper powder, which is used for illustrative purposes only, may be considered the high melting constituent noted at 24 in Fig. 1 that is used wherein the mesh size thereof is preferably about 150. This copper powder 24 is mixed with a binder and a desired quantity of low melting constituent 22 such as tin powder preferably having a mesh size of about 300. In other words, the low melting constituent 22 should be considerably smaller in size of particle than the high melting constituent 24 although the particular sizes noted are not limiting. The binder may be lacquer, oil or liquid plastics, etc., in small quantities, or some other type of binder which will cause the low melting constituent to uniformly adhere to the surface of the high melting constituent. Binders are well known and it has been discovered that in some cases even water may be used. The powders are mixed for a suitable period and are then removed and distributed in a non-compacted condition within a mold on a supporting surface and then sintered. The binder is preferably added to the high melting constituent 24 and coated thereover prior to the addition of the low melting constituent 22. The volatile binding medium is dissipated at the tem-

perature of sintering, leaving the low melting constituent 22 in close proximity to, and in the desired relative position with, the high melting constituent 24, whereupon diffusion takes place with uniformity. It is apparent that the mechanically held layer of low melting constituent 22 is relatively thin compared to the diameter of the metal powder particles and, therefore, diffusion of the low melting constituent 22 into the high melting constituent 24 does not cause any appreciable shrinkage and likewise does not open up large voids.

Another method which may be used to obtain a constituent rich surface on the particles and the one which is preferred, contemplates the attachment of low melting constituent particles 28 to the surface of high melting constituent metal 30 by methods heretofore described, after which the particles are pre-alloyed for a short period, thereby causing superficial diffusion of the tin, for example into the copper. In this embodiment the copper particles 30 are coated with tin 28 which is bonded metallurgically to the copper and forms a constituent rich surface. Upon sintering, the tin further diffuses into the copper and also bonds adjacent particles by an alloy bond.

While the foregoing description has been directed primarily to copper and tin particles, it is apparent that other metals may be used, for example, copper-nickel, wherein the nickel is the high melting constituent and the copper forms the constituent rich surface layer, nickel-tin, wherein the tin is the low melting constituent forming the layer over the nickel particles. Similarly, iron-copper may be used with the copper forming the low melting constituent. It is also possible to use constituent rich surfaces on metal particles wherein the surface itself is an alloy or a mechanical mixture of metals, for example, copper particles may be coated with tin-antimony-lead, or lead-antimony, likewise the high melting constituent may be an alloy, for example, the particle may be a bronze which is coated with tin-antimony, or tin wherein after sintering the tin percentage of the bronze is increased. Likewise if iron is used as the high melting constituent, the iron may include nickel, manganese, carbon, etc., or any other suitable alloying ingredients. These particles may be coated with a low melting constituent, for example, copper. Thus, the invention is directed to the utilization of a constituent rich surface which surface acts as the low melting constituent of the final alloy to be produced and the particular metals or alloys form no part of the invention since such metals depend upon the desired final product.

In all cases it is preferred to use spherical particles to produce uniformity and greater porosity in the finished article. It is apparent that spherical particles in a non-compacted condition present more uniform voids than do comminuted particles made for example by shredding or by electrolysis, etc. This preference is not to be considered a limitation but it is to be understood that spherical particles will produce a more uniform porosity in the finished article, although any of the other types of metal powders may be provided with constituent-rich surfaces by methods heretofore described and thus produce articles from non-compacted metal powders having greater strength than those produced wherein the particles of the constituent metals

are not held in a definite relation to one another prior to sintering.

The invention as described herein is particularly adapted for preventing segregation of the metal powders, for example, when tin powder and copper powder are mixed the constituent metal powders due to the difference in density tend to settle in layers. This is particularly true where there is a difference in the mesh size in the powders or where powders are used which have a variable mesh size which is often the case. In these instances the fines tend to segregate from the coarser particles and similarly the particles of different constituents having different densities tend to segregate in layers. This segregation is due to vibrations of the supporting plate. By following the teachings of this invention it is possible due to the attachment of the low melting constituent to the particles of high melting constituents, to prevent segregation by the fixing of constituent metals in desired relative positions conducive to rapid and uniform alloying. In this manner tin, for example, is held at the surface of the copper particles so that each copper particle has the desired amount of tin in fixed relation thereto which hastens the alloying action whereby alloy bonds are formed between adjacent particles whether or not the sintering is carried out for a sufficient time to cause complete alloying. In some cases it is apparent that if the sintering is not carried out over sufficient time to cause complete alloying, the material will form a bronze at the bonded portions thereof and then shade off toward the nucleus of the copper particles to a copper-rich constituent and possibly at the center of each particle to pure copper. This, of course, depends upon the time of sintering and the desired amount of alloying to be accomplished.

While the foregoing disclosure is directed to procedures using the loose non-compacted powders it is apparent that metal powders of the type described may be advantageously utilized when resorting to molding, such as briquetting, and it is to be understood that the invention is of sufficiently broad scope to be used in connection with any of the well known manufacturing procedures.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a method for reducing the shrinkage of porous alloy articles during sintering which articles are made from non-compacted metal powder, the steps comprising: providing metal powder having at least two metallic constituents of different melting points, particles of said powder including a constituent rich surface thereon, said constituent being the lowest melting constituent and then sintering the powder in the loose non-compacted condition and in desired shape under suitable conditions at a temperature above the melting point of the constituent rich surface metal and below the melting point of the highest melting constituent metal for a time sufficient to cause at least partial alloying of the lower melting constituent with the other constituent whereby the powder is bonded together in an alloy bond without excessive shrinkage.

2. The method as claimed in claim 1 wherein the metal powder having a constituent rich sur-

face thereon consists of high melting point metal having relatively smaller grains of lower melting point metal mechanically attached to the surface thereof.

3. The method as claimed in claim 1 wherein the metal powder having a constituent rich surface consists of grains of metal powder alloy wherein the outer surface comprises a lower melting point constituent than does the inner portion thereof.

4. The method as claimed in claim 1 wherein the constituent rich surface is predominantly tin and the higher melting point metal is rich in copper.

5. The method as claimed in claim 1 wherein the constituent rich surface consists predominantly of copper and the higher melting point metal is predominantly iron.

6. The method as claimed in claim 1 wherein the constituent rich surface is predominantly copper and wherein the higher melting point metal is predominantly nickel.

7. In a method for controlling shrinkage of porous alloy articles during sintering thereof which articles are made from non-compacted metal powder, the steps of fixing the relation of the alloy constituents so that the low melting point constituent is in a relatively thin layer over the higher melting point constituent and then sintering the powder in a non-compacted condition and into the desired shape whereby upon sintering of the powder the diffusion of the metals, as occasioned by alloying, causes a relatively slight change in position of the particles.

8. A method of forming highly porous alloy articles comprising the steps of; providing metal powders having a constituent rich surface thereon wherein the constituents are components of the final alloy desired, distributing a layer of said powder upon a supporting surface in the loose non-compacted condition, and then sintering the layer under non-oxidizing conditions at a temperature above the melting point of the constituent rich surface metal but below the melting point of the metal in the nucleus of the particles for a time sufficient to cause the constituent rich surface metal to diffuse uniformly into each particle, thereby bonding the particles together by an alloy bond for forming a strong homogeneous article without excessive shrinkage, said article having a substantially uniform and controlled porosity.

9. In the method of forming highly porous articles the steps of; providing metal powder particles including at least two component metals which are fixed in definite relation to one another whereby the low melting constituent is adjacent the surface of the particles, distributing a layer of said powder upon a supporting surface in the loose non-compacted condition, and then sintering the layer upon the supporting surface under non-oxidizing conditions at a temperature above the melting point of the low melting component metal for a time sufficient to cause diffusion of the low melting component into the other component metal whereby the particles of metal powder are bonded together by an alloy bond for forming a strong layer without excessive shrinkage, said article having substantially uniform and controlled porosity.

10. In the method of forming highly porous articles the steps of; providing metal powder particles including at least two component metals, which are fixed in definite relation to one another wherein the low melting constituent is adjacent the surface of the particles, filling a mold

with said powder in the loose non-compacted condition, heating the mold with the powder therein under non-oxidizing conditions at a temperature above the melting point of the low melting constituent, but below the melting point of the other component metal for a time sufficient to cause the low melting constituent to diffuse into the high melting constituent for bonding the metal particles together by an alloy bond thereby forming a strong homogeneous article without excessive shrinkage and with a controlled and high porosity, and then removing the article so formed from the mold.

11. In the method of forming highly porous articles the steps of; providing metal powder particles including at least two component metals, which are fixed in definite relation to one another wherein the low melting constituent is adjacent the surface of the particles, loosely molding said powder into the desired shape, and then heating the molded powder under non-oxidizing conditions at a temperature above the melting point of the low melting constituent, but below the melting point of the other component metal for a time sufficient to cause the low melting constituent to diffuse into the high melting constituent for bonding the metal particles together by an alloy bond thereby forming a strong article of substantially uniform controlled porosity and without excessive shrinkage.

12. In the method of forming highly porous alloy articles comprising the steps of; providing metal powder having a constituent rich surface thereon wherein the constituents are components of the final alloy desired, distributing a uniform layer of said powder upon a non-adhering supporting surface in a loose non-compacted condition, heating the layer of powder upon said surface under non-oxidizing conditions at a temperature above the melting point of the constituent rich surface metal but below the melting point of the metal in the nucleus of the particles for the time sufficient to cause the constituent rich surface metal to diffuse uniformly into adjacent particles thereby bonding the particles together by an alloy bond and forming an article of good strength and with a controlled substantially uniform porosity without excessive shrinkage, and then removing the article from the supporting surface.

13. In the method of forming highly porous alloy articles comprising the steps of; providing metal powder having a constituent rich surface thereon which consists of a lower melting constituent than the nucleus of the powder, said constituent being attached to each particle of the powder mechanically, distributing the uniform layer of said powder upon a non-adhering supporting surface in a loose non-compacted condition, heating the layer of powder upon said surface under non-oxidizing conditions at a temperature above the melting point of the constituent rich surface metal but below the melting point of the metal in the nucleus of the particles for the time sufficient to cause the constituent rich surface metal to diffuse uniformly into each particle, thereby bonding the particles together by an alloy bond and forming an article of substantially uniform high porosity without excessive shrinkage, and then removing the article from the supporting surface.

14. In the method of forming highly porous alloy articles without excessive shrinkage during sintering comprising the steps of; providing metal powder particles having a constituent rich

surface thereon comprising a lower melting constituent than the nucleus of the particles, said lower melting constituent being metallurgically bonded by prealloying to the remainder of each particle, distributing the uniform layer of said powder upon a non-adhering supporting surface in a loose non-compacted condition, heating the layer of powder upon said surface under non-oxidizing conditions at a temperature above the melting point of the constituent rich surface metal but below the melting point of the metal in the nucleus of the particles for the time sufficient to cause the constituent rich surface metal to diffuse uniformly into each particle, thereby bonding the particles together by an alloy bond and forming an article of controlled and substantially uniform porosity and of good strength, and then removing the article from the supporting surface.

15. In the method of forming highly porous articles without excessive shrinkage during sintering comprising the steps of; providing copper powder having a high tin layer covering the surface thereof, distributing said powder upon a supporting surface in a loose non-compacted condition, and then sintering the layer under non-oxidizing conditions at a temperature above the melting point of tin and below the melting point of copper for a time sufficient to cause the metals to diffuse whereby bronze bonds are formed between adjacent particles and the finished article has a controlled and substantially uniform porosity and is of good strength.

16. In the method of forming highly porous articles without excessive shrinkage during sin-

5 tering comprising the steps of; providing nickel powder having a thin layer of copper covering the surface thereof, distributing said powder upon a supporting surface in a loose non-compacted condition, and then sintering the layer under non-oxidizing conditions at a temperature above the melting point of copper and below the melting point of nickel for a time sufficient to cause the metals to diffuse whereby copper-nickel bonds are formed between adjacent particles for forming an article of substantially uniform and controlled porosity and of good strength.

17. In the method of forming highly porous alloy articles without excessive shrinkage during sintering comprising the steps of; providing pre-alloyed powders wherein the extent of pre-alloying is limited to the surface thereof so that the surface of each particle is rich in a low melting constituent, distributing said powder upon a supporting surface in a loose non-compacted condition, and then sintering the layer under non-oxidizing conditions at a temperature above the melting point of low melting constituent and above the melting point of the remainder of the metal particle for a time sufficient to cause the constituents in the powder to further diffuse whereby alloy bonds are formed between adjacent particles for forming an article of substantially uniform and controlled porosity and of good strength.

18. The method as claimed in claim 9 wherein the porous layer is bonded to the supporting surface.

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