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POROUS METAL

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This invention relates to ferrous articles and is particularly concerned with porous ferrous articles wherein the articles are made from powdered metal.

An object of the invention is to utilize phosphorus as a bonding agent for particles of metals consisting of iron and another metal which forms solid solutions with iron in all proportions and wherein the phosphorus forms eutectics with the iron and the other metal whereby the lowest melting constituent of the three elements is utilized as a bonding agent.

In carrying out the above object, it is a further object to sinter the articles, in some cases, for periods of time sufficient to cause more or less complete diffusion of the phosphorus into both of the metals used for forming an alloy therewith which approaches homogenity.

Another object of the invention is to use iron and cobalt, iron and nickel, nickel and cobalt and/or combinations thereof etc., together with phosphorus in quantities commensurate with the degree of brittleness permissible in the finished article.

Still another object of the invention is to add phosphorus to the mixture of the metals in the form of ferro-phosphorus, wherein the percentage of phosphorus in the ferro-phosphorus is preferably above 10.2%.

Further objects and advantages of the present invention will be apparent from the following description.

In my application S. N. 306,703, copending herewith and now matured into Patent No. 2,226,520 I have disclosed a method of bonding compressed particles of substantially pure iron powder together by means of a eutectic of iron and its phosphide. In application Serial No. 344,132, filed concurrently herewith I have disclosed the use of the eutectic between a single elemental metal and its phosphide as a bonding medium for the elemental metal in its loose noncompacted condition. The present application is directed to alloy systems including two or more metals which form solid solutions with each other in any and all proportions, together with phosphorus. Systems of this character include various alloys for example, iron-nickel, iron-cobalt, nickel-cobalt and/or combinations thereof. In each case, the metals form solid solutions throughout their entire range of compositions. On the other hand, each of the metals mentioned form binary eutectics with the non-metal phosphorus, such binary eutectics being disclosed in the aforementioned application Serial No. 344,132.

In the case of the addition of phosphorus to binary systems between any of the metals mentioned, it is my theory that a ternary low melting alloy constituent is formed which ternary alloy may be used as a bonding agent and thus iron and nickel for example, in the powdered form, can be bonded together into a strong article by means of the low melting ternary alloy constituent without approaching the melting point of either of the metals. Heretofore, it has been impossible to strongly bond iron and nickel, for example, together in the loose noncompacted condition unless the melting point of iron has been exceeded and thus if it is desired to form an article predominant in iron, it has been necessary to resort to briquetting in order to get close enough association between the grains of metal, or it has been necessary to use a low melting bonding metal such as, copper which in most cases is not desired when an iron-nickel article is required. It is apparent, the briquetting is not always a desirable expedient, particularly when highly porous articles are desired.

I propose to add the phosphorus to the mixture of metal powders in the form of ferrophosphorus, nickel phosphorus etc., in the preferred embodiment, altho it may be added in the form of elemental red phosphorus if suitable precautions are employed as are well known to those skilled in the art. When using ferrophosphorus as a phosphorus carrier, I prefer to have the percentage of phosphorus therein above 10.2% which is the phosphorus percentage in the eutectic between iron and its phosphide. However, since the ternary eutectics of these systems are, for the most part, largely unexplored, I prefer to use a maximum percentage of phosphorus in an article corresponding to the percentage of phosphorus in the binary eutectic which forms the lowest percentage eutectic with phosphorus. However, it is to be understood that under suitable conditions higher percentages of phosphorus may be employed. However, such percentages are best arrived at by trial in order to obtain an article having the desired physical characteristics, because phosphorus, when added in sufficient quantities, tends to increase the brittleness of the article.

The sintering temperature employed in the formation of articles of this type should be between the melting point of the lowest melting constituent and the melting point of the lowest melting metal. In this manner, the eutectic is the low melting constituent and causes particles of the two metals to be bonded together without

causing either of the metals to pass into the liquid phase. By using the method proposed herein it is possible to make articles of iron and nickel wherein the percentages of iron and nickel vary over a wide range. Likewise, it is possible to make alloys with cobalt, cobalt and nickel etc., by a similar procedure.

While I have disclosed the addition of phosphorus to the mixture in the form of ferrophosphorus, it is understood that phosphorus may be added as cobalt-phosphorus or nickel phosphorus etc. I prefer to use ferrophosphorus since this material is readily obtainable on the market whereas the others must be prepared. Likewise, while I prefer to use mixtures of elemental metal powders it is to be understood that metals may be alloyed prior to preparation of the metal powder wherein each metal particle is itself an alloy of two metals.

Specific sintering temperatures for mixtures of the various metals are preferably as follows: For iron and nickel with phosphorus 2000° F. For iron and cobalt with phosphorus 2000° F. For cobalt and nickel with phosphorus 2000° F. In each case, the mixture of metal powders and phosphorus carrier is heated under suitable nonoxidizing conditions for a time of from 10 minutes to an hour and then cooled under suitable nonoxidizing conditions. The period of sintering controls the degree of diffusion of the alloying ingredients which may vary from particles of iron and another metal, for example, bonded by means of a low melting constituent or, when the sintering is carried out over a sufficient period of time, to cause more complete diffusion, to a more homogeneous alloy of iron, phosphorus and the other metal.

While the method described herein is best suited for use in the manufacture of articles from noncompacted metal powders, it is to be understood that similar procedures may be resorted to when operating on briquetted materials altho in this case the use of phosphorus is usually unnecessary since two constituent metals are used.

While the foregoing description has been limited to the use of substantially pure metals, it is to be understood that conventional alloying ingredients such as, carbon, silicon, vanadium, manganese, chromium, molybdenum etc., may be added in quantities up to 5% without changing the conditions or results described herein.

While the embodiments of the present invention as herein disclosed, constitute preferred forms, 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 the method of making highly porous metal articles from a mixture of at least two metals which are soluble in one another in all proportions in the solid state and which metals form phosphides, the steps comprising adding to the mixture of the metals phosphorus in quantities sufficient to form a low melting constituent between the metals and their phosphides, heating the metal powders with the phosphorus therein to a temperature exceeding the melting point of said constituent but below the melting point of the elemental metals under suitable conditions and for a time sufficient to cause the metal powder particles to be bonded together into a highly porous article by the low melting constituent.

2. In a method of making highly porous ferrous articles from a mixture of iron with another metal when the iron and said other metal are soluble in each other in all proportions in the solid state and which form phosphides, the steps comprising adding to the mixture of iron and the other metal phosphorus, heating the metal powders with the phosphorus therein to a temperature exceeding the melting point of the lowest melting constituent but below the melting point of iron or the other metal under suitable conditions and for a time sufficient to cause the formation of a eutectic mixture which bonds adjacent metal particles together into a porous article.

3. The method as claimed in claim 1 wherein the one metal is cobalt and the temperature of heating is approximately 2000° F.

4. The method as claimed in claim 2 wherein the metal is nickel and the temperature of heating is approximately 2000° F.

5. The method as claimed in claim 1 wherein one of said metals is nickel.

6. The method as claimed in claim 1 wherein the metals are iron and nickel.

7. A new article of manufacture consisting of a highly porous article including phosphorus, iron, another metal which is soluble therein in any and all proportions in the solid state which iron and other metal form phosphides, said article being formed by sintering a non-compacted mixture of the components at a temperature below the melting point of any of the metals.

8. A new article of manufacture consisting of a highly porous article of iron, nickel and phosphorus, said article being formed by sintering together a non-compacted mixture of the components at a temperature below the melting point of iron or nickel.

9. A new article of manufacture consisting of a highly porous article of iron, cobalt and phosphorus made by sintering together a mixture of the components at a temperature below the melting point of iron or cobalt.

10. A new article of manufacture consisting of phosphorus and at least two metals which are soluble in one another in any and all proportions in the solid state and which metals form phosphides, said articles being formed by sintering together a non-compacted mixture of components at a temperature above the melting point of the phosphides of the metals with the phosphorus but below the melting point of any of the metals.

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