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## PROCESS OF UNITING IRON WITH OTHER METALS AND ELEMENTS

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This invention relates to a process of uniting iron with other metals and elements, and has to do particularly with the process of combining finely divided metallic iron with other metals and elements under a temperature and pressure, but without melting of the iron.

Heretofore in the combining of iron with other metals to form alloys, it has been the practice to raise the temperature of the iron to its melting point and to form the alloy by combining or adding the particular metal or metals or elements to the molten iron. The resulting alloys produced in the past have been of a very high quality, but the cost of production has been relatively high due to the steps and procedure involved in raising the iron to a melting temperature, and the pouring into forms or molds while molten.

It is the object of the present invention to combine metals or elements with the iron at a temperature less than the melting point of the iron whereby to form a finished alloy without melting or forging of the iron. Another object of the invention has to do with the process of associating iron in finely divided or porous form with other metals under pressure and to maintain the combined elements under pressure at temperatures below the melting point of the iron whereby the metals so associated become sintered and alloyed with the iron.

In carrying out my invention, I preferably utilize an iron which I term "sponge iron", which is an iron produced by the separation of oxygen from iron ore without melting. Sponge iron has been produced by many different forms of apparatus and methods, and although a good quality of sponge iron has been produced in many cases, the cost of the production of the iron has been so prohibitive as to prevent its use on a commercial scale. Many improvements have been made along this line recently, and it is the object of the present process to utilize such sponge iron produced by the reduction of iron ore at relatively low temperatures. Therefore, in carrying out the present invention, I preferably utilize an iron ore of a porosity as produced in the separation of oxygen from the iron ore by reduction without melting. It will be understood, however, that an iron may be utilized which has a porosity such as produced by the electrolytic decomposition of iron. In other words, in carrying out my process, I preferably utilize an iron which is open in its atomic form, or what might be called atomically divided. Such sponge iron may be produced by the method and apparatus disclosed in my co-pending application, Serial No. 88,774, filed Feb. 17, 1926.

In carrying out my process, the finely divided metallic iron is associated with the particular metal or metals, or elements, in the portions desired in accordance with the quality and strength of the alloy desired. The iron and associated metals or elements are then placed under pressure at a temperature which is sufficient to fuse the alloy metal or metals, but at a temperature lower than the melting point of the iron. By fusing it will be understood that the metal or element to be combined with the iron is raised to either its melting or plastic state which ordinarily should be considerably below the fusing point of iron, which is around 1530° C. The finely divided iron and other metals or elements having been pressed together while in granular condition and brought to the desired temperature, less than melting point of iron, the metals or elements of the lower melting or fusing point will unite with the sponge or finely divided iron to form an iron alloy which may be commercially used. The iron being in open or porous form, the metal of lower melting point will wet, impregnate and alloy with the porous iron whereby the iron will be evenly and completely saturated throughout by such metal or metals forming an alloy of same. By this process the iron is not raised to its melting point, and the resulting bars or other forms of iron so alloyed are finely pressed into a compact mass thus entirely doing away with the melting or forging of the iron as has been the practice in the past. For example, if iron-tin or iron-nickel alloys are to be formed, the sponge iron is combined with the correct proportions of tin or nickel and subjected to a temperature of approximately the fusing point of tin, or

nickel, as the case may be, which is much lower than the melting point of iron. The added element will unite with finely divided iron and the mixture subjected to pressure whereby an iron alloy is formed in bond of the desired shape.

At the time of combining the iron with non-ferrous metals, the non-ferrous metals are preferably in a finely divided form, and are associated with the iron and subjected to temperature and pressure to give the form density, such metals being subjected to unoxidizing temperature at less than the melting point of the iron. In the case where metals of about the same melting temperature as iron are to be alloyed with the iron, I prefer to conduct the uniting of the elements under reduction conditions in gases such as hydrogen or carbon-monoxide.

It will be understood that, in addition to the various metals, carbon may be united with the sponge or finely divided iron by combining the iron and carbon under pressure and temperature. In this case some of the carbon is combined inherently with the iron particles and some of the carbon is held mechanically as a result of the pressure applied in forming the desired shapes of the combined iron and carbon. It will be obvious that by uniting the carbon with the reduced sponge iron, both by inherent combination and by holding the same mechanically, that the amount of carbon and particular density of the carbon at any particular point or part of the compressed bar or form may be easily predetermined, and that many available articles may be thus produced. The particular articles which may be formed by such process and particular manner of forming the same, is unimportant as far as the present invention is concerned, as such articles and manner of forming the same will form the part of a separate application.

It will also be understood that having once procured the sponge iron that any convenient retort and apparatus may be utilized for bringing the metal or element to be alloyed with the iron up to the proper fusing temperature and for effecting compression and pressing of the mixture and alloy of the desired shape. It will be obvious that there will be times when the iron alloy at relatively low temperatures should be in some preferred state of temperature for final compressing. Whatever shape may be desired may be impressed upon the iron alloy at the time that the metal or other element is united with the iron. In other words, I have made it possible to form an iron alloy from a finely divided metallic iron and other metal or element by simply effecting the uniting under pressure at a temperature lower than the melting point of the iron and to simultaneously effect the formation of any desired shape alloy at the time that the metallic iron and other metal or element be subjected to the alloying pressure.

In other words, in carrying out my novel process, I preferably take the finely divided iron, together with the alloy or alloy forming element, and, while still comparatively cold, compress the same into the general desired form or forms. The iron and alloy particles are thus held together by adhesion and not united. Such form or forms may then be placed in an oven at the proper temperature, less than the melting point of the iron, to partly fuse or sinter the mass. When partially sintered or fused, and in the general form desired, the whole mass is then brought up to the desired temperature of alloying and subjected to pressure or squeezed in proper dies or forms so as to close in all the grains into a solid uniform mass.

It will be understood that either the term "sponge iron" or "finely divided metallic iron" as used in the claims, is broad enough to cover any iron having a porosity similar to that produced in the separation of oxygen from iron ore without melting or an iron having a porosity similar to that produced by the electrolytic decomposition of iron.

What I claim is:

1. The process of forming iron alloys which consists in associating finely divided iron with the alloy elements while still comparatively cold, compressing the associated iron and alloy metals into the general desired form or forms, whereby to hold the same together by adhesion, subjecting said form or forms to a temperature less than the melting point of the iron to partly fuse the mass, bringing the partly fused mass up to the desired temperature for alloying, and then alloying by subjecting the general form or forms to pressure whereby to close in all the grains into a solid uniform mass of final shape or shapes.

2. The process of forming iron alloys which consists in associating finely divided iron with the alloy forming elements while still comparatively cold and compressing the same into the general desired form or forms, whereby to hold the same together only loosely by adhesion, subjecting said form or forms to the desired temperature for alloying, equal to the wetting temperature of all the alloy forming elements but less than the melting point of the iron, and then subjecting the general form or forms to pressure, while at alloying temperature, whereby to close in all the grains into a solid uniform mass of final shape or shapes.

3. The process of forming iron alloys which consists in associating finely divided iron with the alloying elements while still comparatively cold, compressing the mixture into the general desired form or forms with only sufficient pressure to hold the same together by adhesion, subjecting the mixture to an alloying temperature greater than the wetting tem-

perature of all of the said alloying metals or elements but less than the melting temperature of the iron, and then subjecting the mixture to pressure while at alloying temperature whereby to close in all of the grains to form a final article.

4. The process of forming iron alloys which consists in combining finely divided iron with a plurality of alloying elements, compressing said mixture into a generally desired form or forms with only sufficient pressure to hold the form or forms together by adhesion, heating the form or forms to a temperature less than the melting temperature of the iron but sufficient to partly fuse the mass, bringing the fused general form or forms to the desired temperature for alloying, greater than the wetting temperature of all of said alloying elements, and then subjecting the general form or forms, while at substantially said alloying temperature, to pressure whereby to close in all the grains into a solid uniform mass of final shape or shapes.

In testimony whereof I have affixed my signature.

WILLIAM H. SMITH.