

UNITED STATES PATENT OFFICE

2,193,435

UNITING OF FINELY DIVIDED IRON WITH
OTHER METALSWilliam H. Smith, Detroit, Mich.; Kathryn L.
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ceasedNo Drawing. Application July 29, 1936, Serial No.
93,172. Renewed July 22, 1939

9 Claims. (Cl. 75—22)

This invention relates to the uniting of finely divided iron with other metals. Heretofore, in the uniting of finely divided iron, such as sponge iron, with other metals, it has been customary, as set forth in my Patents No. 1,775,358 of September 9, 1930, and No. 1,951,499 of March 20, 1934, to mix the finely divided iron and other elements together in a predetermined relationship before shaping, said finely divided other metals and elements being either in their natural form or their oxide state.

It is the object of the present invention to obtain the combining and the alloying or partial alloying by introducing the alloying elements from the outside of a mass of finely divided iron. It has been discovered that finely divided metallic iron or sponge iron of the type reduced from the ore without melting forms into a high crystalline state above 2000° F. and, of course, below its melting temperature of approximately 2800° F.

It is another object of the present invention to alloy or partially alloy the finely divided iron with non-ferrous metals at temperatures sufficient to produce fluidity of the non-ferrous metals so that the fluid non-ferrous metals will penetrate into and unite the finely divided iron and alloy therewith at the grain boundaries of the iron. The non-ferrous metals penetrating into the mass of finely divided iron not only forms a bond for uniting the iron particles but fills those portions which heretofore have been voids or contain metallic oxides, etc., with non-ferrous metal.

Another important feature of the present invention has to do with the use of an acid slag, introduced into the mass of finely divided iron in some form, and the heating of this acid slag to a temperature sufficient to render the same fluid; the acid slag attacking and removing the metallic oxides, the acid slag and the oxides being removed by sintering and/or pressing of the mass of finely divided iron, the removed oxides and slag being replaced by a non-ferrous metal.

In carrying out the invention I preferably use an iron which I term "sponge iron" which is an iron produced by the separation of oxygen from iron ore without melting. In carrying out my preferred process the finely divided metallic iron is first fabricated into any desired form by rolls or pressing and then sintering, or by placing in a mold and bonding, or any other well known fabrication process. The density of this mass of finely divided iron may, of course, vary considerably but once having been formed into the desired shape it is immersed in a molten bath

of non-ferrous metal such as copper, nickel, aluminum, or any other combination containing non-ferrous metals.

The mass of finely divided iron may be heated above 2000° but less than its melting temperature before immersion, or it may be brought to a temperature above 2000° by the immersion step, if the non-ferrous bath is above said 2000° F., or operate at such lower temperatures as fluidity of the non-ferrous bath permits to effect its entering the mass of finely divided iron.

It will be understood that the present process relates only to finely divided iron not molten and that it also deals with any combination of non-ferrous metals and that the heat may be applied to both the iron form and the non-ferrous metal simultaneously or separately; the gist of this step is that the molten non-ferrous metals enter the crystalline structure of the iron form or mass from the outside.

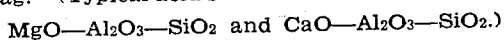
It will be understood that the form of finely divided iron may be mechanically pressed or placed under temperature but that when it is brought to the required temperature of above 2000° it will be in a crystalline sintered form. In one form of carrying out the invention the iron form may be cylindrical in shape and then immersed in a bath of non-ferrous metal, the step being carried out in a reducing or non-oxidizing atmosphere. The copper or nickel or other metal will flow in and around through the crystals formed by the finely divided iron particles and alloying thereto, the alloying step taking place particularly at the grain boundaries of the iron.

By this process it will be seen that I am using the second non-ferrous metal, whatever may be its form, to unite the crystals formed in the finely divided iron mass at a predetermined temperature. The step greatly increases the ductility of the form and renders the same practically rustless and very strong. In the case of the cylindrical form the interior thereof may be subjected to one kind of non-ferrous metal and the exterior to another kind of non-ferrous metal so that the same may be used as a bearing. When the article is removed from the bath the surplus may, of course, be drained off.

A preferred method of treating the finely divided iron form and of getting a non-ferrous metal into the form, where the finely divided iron contains metallic oxides, and particularly iron oxides, is to subject such oxides to a fluid acid slag. The acid slag in its natural state may be mixed with the finely divided iron or may be introduced from the outside in a molten

state, or the finely divided iron form may be immersed in a bath containing a molten non-ferrous metal and an acid slag. Whatever the form in which the acid slag is introduced into the iron form, such acid slag will remove the basic oxide formed in the voids and grain boundaries of the iron form and replace the same with a molten non-ferrous metal. When the finely divided iron form is subjected to the sintering temperature it materially contracts to a lesser volume and in doing so forces or squeezes out the slag and oxides; if the form is subjected to pressure as well as temperature, this application of pressure will serve to assist in squeezing out slag and oxides, the non-ferrous metals having a greater surface tension will remain in the voids and grain boundaries. Thus it will be seen that I may introduce the alloying non-ferrous metals into the form regardless of whether the voids and grain boundaries in said form are entirely open and free or whether they are filled with an oxide.

The acid slag, which may be utilized to remove the basic iron oxide or the like, may be borax, acid silicates, or any well known acid slag. (Typical acid silicates are



It will be understood here that the iron oxide may be present in the sponge iron when reduced or the iron form may be subjected to an oxidizing temperature; in either case, the step of removing the iron oxide or the like, may take place in a reducing or oxidizing atmosphere, as the acid effect overcomes any atmosphere condition.

As a general rule, silica will be present in the reduced sponge iron along with a small amount of iron oxide occasioned by its complete reduction. The silica is acid and has a high melting point, but by adding sodium carbonate to the briquet the resulting compound has a materially reduced melting point; I prefer to add a relatively small amount of sodium carbonate as compared to the silica and, while the sodium carbonate is basic, when compounded with the silica, the resulting compound remains predominately acid. The compound of silica and sodium carbonate produces an extremely fluid acid slag and this will tackle the iron oxide and remove the oxide from the metallic iron of the form. Thus, by adding the sodium carbonate to the silica I materially reduce the melting point, obtain a very fluid acid slag which cleans the sponge iron form and takes out the iron oxide. In place of sodium carbonate I may use potash, sodium chloride, or similar compounds which will reduce the melting point and increase the fluidity of the silica, as an acid slag.

Whether the acid slag used in removing the oxide is formed by the adding of powdered sodium carbonate or the like to the silica already in the form, or by adding boric acid or the like or by combining the molten slag with molten non-ferrous metal bath, the slag used is preferably one that becomes relatively fluid at some point below the melting point of iron. The melting of the slag is an exothermic action, and creates heat, and if an acid slag were used that melted, say, at 2000° and the briquet is sintered at 2000°, then the treatment would take a very few minutes; it is a question of time and temperature, and in some cases where the temperature would not be sufficient to produce the exothermic action and the slag melted very slowly, as long as half an hour would be required for the treatment. The

fluid acid slag cleans the lattice-work and the grain boundaries by freeing the iron oxide or the like from the iron with which it was associated or combined.

The acid slag treatment has a beneficial action regardless of the introduction of non-ferrous metals into the form; if molten non-ferrous metals are not introduced into the interstices and the grain boundaries of the form, a small amount of acid slag will remain and give a beneficial rust protection when the form is finally pressed or rolled to shape.

Even if the forms of finely divided iron were to be subjected to a melting temperature, it would still be possible to slag out the oxides before reaching the melting point of the iron, so that the oxides are not carried into the molten bath.

By predetermining the composition of the slag in the finely divided iron briquets or forms, so that slagging takes place before the iron becomes molten, it is possible to utilize the phenomena of metallic contraction produced by the sintering of finely divided iron to squeeze out the slag and associated oxides to clean the iron form. It will also be obvious that pressure applied during or just after the sintering step will materially assist in the squeezing out of slag and oxides. The final forms in my process may be subjected to further working such as through rolls, extrusion, or to any kind of working whatsoever, although it will be distinctly understood that such forms are commercially usable immediately after the alloying or partial alloying step.

In another modified process I may use a vitreous enamel powder which may be placed on the outside of the form or for that matter may be mixed with a considerable portion of the cross sectional area of the finely divided iron mass or form. The form may be shaped or worked as desired into sheets or into the final article and when the form is subjected to the fusing temperature, as is customary in enameling articles, the enamel will be permanently locked within the finely divided iron adjacent the surface of the article thus eliminating all flaking and making permanent union of porcelain and iron in composite mass.

What I claim is:

1. The process of forming iron which consists in subjecting a mass of sintered finely divided iron having iron oxide in the voids and grain boundaries thereof to a bath of acid slag containing molten non-ferrous metals of such fluidity as to enter the interstices of the mass, removing the oxide in the mass of finely divided iron by said slag and replacing the same with non-ferrous metal.

2. The process of forming iron which consists in subjecting a mass of finely divided iron having been sintered and having iron oxide in the voids and grain boundaries to a bath of molten acid slag, thereby removing the iron oxide in the mass of finely divided iron by said slag and then replacing such slag with molten non-ferrous metals.

3. The process of forming composite metallic articles which consists in forming finely divided iron particles into any desired shape, a portion of said shape containing iron oxide, sintering and predetermining the porosity and crystalline structure of said shape by preheating and then subjecting said shape to an acid slag whereby said fluid slag enters the voids and interstices of said shape.

4. The process of forming substantially rust proof composite metallic articles which consists

in forming finely divided iron particles into any desired shape, predetermining the porosity and crystalline structure of said shape by preheating and sintering, the iron and similar oxides concentrating at the grain boundaries formed by sintering, subjecting said sintered shape to a bath of acid slag of such a nature and fluidity as to enter the voids and grain boundaries and react with and remove the basic oxides at such grain boundaries.

5. The process of forming substantially rust proof composite metallic articles which consists in forming finely divided iron particles into any desired shape, predetermining the porosity and crystalline structure of said shape by preheating and sintering, the iron and similar oxides concentrating at the grain boundaries formed by sintering, subjecting said sintered shape to a bath of acid slag of such a nature and fluidity as to enter the voids and grain boundaries and remove the basic oxides at such grain boundaries, and replacing the oxides removed from said grain boundaries with a molten non-ferrous metal.

6. The process of forming iron which consists in subjecting a mass of finely divided iron having metallic oxides in the voids and grain boundaries thereof to fluid acid slag and fluid non-ferrous metal of such fluidity as to enter the interstices of the mass, subjecting the mass of finely divided iron to a sintering temperature sufficient to contract the finely divided metals and squeeze out the slag and oxide but retaining at least a portion of the non-ferrous metals.

7. The process of forming iron which consists in forming a mass of finely divided iron having iron oxide in the voids and grain boundaries thereof, introducing an acid slag into the said mass of the type that will have sufficient fluidity as to enter the interstices of the mass when subjected to a temperature less than the melting point of the iron, subjecting the mass of finely divided iron and slag to a sintering temperature sufficient to predetermine the porosity and crystalline structure of the mass, the sintering temperature being sufficient to melt the acid slag

whereby the same attacks the basic iron oxide and sufficient to contract the mass to squeeze at least a portion of the fluid slag and iron oxide therefrom.

8. The process of forming iron which consists in forming a mass of finely divided iron having iron oxide in the voids and grain boundaries thereof, introducing an acid slag into the said mass of the type that will have sufficient fluidity as to enter the interstices of the mass when subjected to a temperature less than the melting point of the iron, subjecting the mass of finely divided iron and slag to a sintering temperature sufficient to predetermine the porosity and crystalline structure of the mass, the sintering temperature being sufficient to melt the acid slag whereby the same attacks the basic iron oxide and sufficient to contract the mass to squeeze at least a portion of the fluid slag and iron oxide therefrom, and subjecting said mass of finely divided iron to pressure to assist in squeezing out the fluid slag and oxide.

9. The method of treating finely divided iron reduced without melting, of the type having a small amount of silica and other oxides, which comprises mixing a quantity of sodium carbonate with the mass and compressing the same into a predetermined shape, heating the mass to a sintering temperature under the melting point of iron but sufficient to form iron crystals, whereby the iron and similar oxides are concentrated at the grain boundaries formed by the sintering step, the quantity of sodium carbonate being sufficient relative to the silica that when the mass is further sintered, but still under the melting point of the iron, the molten sodium carbonate will combine with the silica to form a resulting silicate which remains acid in its effect and continuing the sintering of the form at a temperature sufficient to contract the mass and utilizing the metallic contraction of the finely divided metals to squeeze out at least a portion of the silicate and associated oxides.

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