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METHOD AND MATERIAL SUITABLE FOR USE
IN THE PRODUCTION OF MOLTEN METAL
PRODUCTS

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This invention relates to metallurgy and has for an object the provision of improved metallurgical processes and materials. An important object of the invention is to provide an improved method of altering the compositions of metal products containing iron. Another important object of the invention is to provide improved exothermic mixtures suitable for use in the production of metallic iron. A more specific object of the invention is to provide a novel method of producing metallic iron products suitable for use in the production of high-strength castings from metal, of the type commonly produced in foundry cupolas, which is suitable for use in the production of relatively low-strength castings. The invention further contemplates the provision of improved methods and materials for increasing the temperatures of molten metal baths, for adding silicon to molten metals, for adding alloying elements to molten metals and for melting metals such, for example, as powdered iron, nickel and copper shot and scrap iron and steel products including borings, clippings, punchings and the like.

The invention will be described hereinafter more particularly with respect to its use in the production of metal suitable for use in the production of high-strength castings, but it is to be understood that certain features are useful in general metallurgical procedures involving the production of metallic iron-bearing products.

In the production of metallic iron products suitable for use in the production of high-strength castings, the invention employs the principle of dilution of relatively impure metallic iron products with relatively pure metallic iron to form resulting products containing metallic iron in increased proportions and, consequently, containing other components in proportions smaller than in the relatively impure products subjected to treatment. In accordance with the invention, dilution is effected by reacting in contact with the impure metallic products, while molten, exothermic mixtures capable of reacting to produce relatively pure molten iron.

In many foundries, operations are confined for the most part to the production of metallic iron products suitable for use in the production of ordinary soft iron, or low-strength, castings, products containing for example, about 3.15 percent carbon and about 2.25 percent silicon. Iron products suitable for use in producing relatively high-strength castings (products containing, for example, about 2.9 percent carbon and about 2.0 percent silicon) require careful control of the

production processes or special equipment for their production. The average small foundry is not provided with the special equipment or the necessary technical supervisory facilities to produce such products, and consequently, the output of such a foundry is limited to products which can be produced by means of simple operations of the type of cupola operations.

The present invention permits the operations of foundries to be made more flexible by enabling ordinary foundry operators to modify or alter, conveniently and accurately, the composition of all or any part of the material produced in any furnace heat without the necessity for employing special equipment. The invention provides exothermic mixtures capable of producing relatively pure metallic iron in definite quantities per unit of weight, and, by means of simple calculations, a foundry operator may determine the proper quantity required to effect dilution of ordinary soft iron to the extent desired to form a product containing iron, carbon and silicon in desired proportions. Cupolas may be operated as usual to produce the customary soft iron product, and dilution can be effected by addition of the exothermic mixtures to the ladles commonly employed for receiving molten metal from the cupolas.

The invention also provides exothermic mixtures capable of delivering to molten metal baths definite quantities of silicon and alloying metals such, for example, as copper, nickel, chromium, cobalt, vanadium, tungsten molybdenum, titanium and manganese alone or in various combinations with iron or with iron and one another.

The exothermic mixtures of the invention comprise particles of silicon-containing materials such as ferro-silicon and oxidizing materials consisting of one or more oxidizing agents such as alkali metal nitrate or alkali metal chlorate (sodium nitrate or sodium chlorate) which is free of metallic elements reducible to the elemental state by silicon. They may include also particles of one or more relatively pure metals such as iron and the alloying elements hereinbefore referred to, fluxing material such as lime capable of fluxing silica formed by oxidation of silicon and one or more reducible metal compounds, such as the oxides of iron and the oxides of alloying elements. The reaction mixtures may include also the calcium ferrite product (calcium oxide chemically combined with ferric oxide) which is described in my copending application Serial No. 253,440, filed January 28, 1939. In accordance with the disclosure of said co-

pending application, lime (CaO) and ferric oxide may be combined chemically by heating a mixture of the two materials in finely divided forms and under non-reducing conditions to a temperature of about 1200° C. or higher.

Reaction mixtures suitable for use in introducing relatively pure molten iron or molten iron and molten silicon into molten metal baths may consist of ferrosilicon and oxidizing material such as sodium nitrate or sodium chlorate, or they may consist of silicon or ferrosilicon, oxidizing material and particles of relatively pure iron. If relatively pure iron alone is to be produced, the silicon and oxidizing material of the mixtures will be employed in amounts and proportions such that all of the silicon will be consumed and sufficient heat to melt all of the iron present (including the metallic iron of the ferrosilicon) will be developed. When a reaction mixture of the invention is to be employed for incorporating both silicon and iron in a molten metal bath, silicon will be employed in the mixture in excess amount corresponding to the amount to be incorporated in the molten metal bath, the silicon and oxidizing material will be employed in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon will generate sufficient heat to melt the residual silicon and any metal present.

Reaction mixtures for incorporating iron or iron and silicon in molten metal baths may comprise silicon-containing material such as ferrosilicon, oxidizing material such as sodium nitrate or sodium chlorate, particles of metallic iron and lime, or iron oxide, or lime and iron oxide or calcium ferrite (calcium oxide chemically combined with ferric oxide). If such a reaction mixture is to be employed for introducing both iron and silicon into a molten metal bath, silicon should be present in an amount in excess of that required to reduce any iron oxide present and develop by reaction with all of the oxidizing material sufficient heat to melt all metallic iron present as such in the mixture, all metallic iron produced by reduction of any iron oxide present and the excess silicon. The excess of silicon employed will correspond to the amount to be incorporated in the molten metal bath. If a reaction mixture of this type is to be employed for incorporating molten iron only in a molten metal bath, silicon and the oxidizing material may be employed in the mixture in the amounts required to provide silicon for reducing all iron oxide which may be present and to develop by reaction of silicon with the oxidizing material sufficient heat to melt the metallic iron present initially and the metallic iron produced by reduction of iron oxide, or, the silicon may be employed in a more limited amount such that only a portion of any iron oxide present will be reduced and the unreduced iron oxide will function to increase the fluidity of any slag produced.

In producing an exothermic mixture in accordance with the invention, I may employ one part by weight of silicon for oxidation to not less than about twenty (20) parts by weight of metal to be melted. I prefer to provide about one pound of silicon for oxidation to about twenty-two to twenty-five pounds of metal to be melted (including silicon, metal present in the mixture as such and metal produced by reduction upon ignition of the mixture) and to provide a sufficient amount of an oxidizing agent such as sodium nitrate or sodium chlorate to oxidize all of the silicon provided for oxidation. Oxidation of sili-

con with the development of suitable quantities of heat and suitably high temperatures may be accomplished satisfactorily by providing sodium nitrate and silicon for oxidation in the proportions, three and one-half to four (3.5 to 4.0) parts by weight of sodium nitrate to one (1.0) part by weight of silicon.

In forming various reaction mixtures of the invention, silicon may be employed as such or in the form of any suitable silicide, such, for example, as a silicide of iron or an alloying element. When the silicon is employed in the form of ferrosilicon, any grade of ferrosilicon may be employed. The lower limit (percentage) of silicon in ferrosilicon employed will be determined by practical crushing or grinding considerations and by carbon requirements, and the upper limit will be determined by results sought to be accomplished. Ferrosilicon products containing less than about fifteen to twenty percent (15 to 20%) of silicon are difficult to crush to suitably small particle sizes. Lower grades of ferrosilicon contain relatively higher percentages of carbon. Higher grades of ferrosilicon (ferrosilicon containing higher percentages of silicon) may be employed advantageously when silicon is to be incorporated in molten metal baths and when the reaction mixtures to be produced are to contain relatively large burdens of metals, reducible metal compounds and slag-forming materials.

The components of reaction mixtures of the invention may be employed in the form of particles of any suitable sizes. The components, such as the silicon-containing material, reducible metal compounds, oxidizing material and fluxing materials, which enter into chemical reactions upon ignition of the reaction mixtures preferably are employed in the form of particles minus 100-mesh in size in order to provide for intimate contact which promotes efficiency in reaction. Components which do not enter into the reactions, such as metals (iron and alloying metals) and silicides which may be provided when increase in the silicon content of molten metal is sought, may be employed in the form of particles of relatively large sizes. The sizes of the particles of non-reacting materials need be limited only by the capacity of the reaction mixture, in the form in which it is employed, to retain the particles within the body of the mixture in the effective reaction zone upon ignition.

When the components are all in the form of relatively small particles (for example, minus 100-mesh) the reaction mixtures may be employed in the form of loose powders or they may be employed in the form of agglomerates in which the particles are bonded together by a bonding agent like sodium silicate or by means of the oxidizing material employed. When the reaction mixtures contain relatively large particles which might settle out of the mixtures if the mixtures should be placed in loose form on the surfaces of molten metal baths, it is desirable to agglomerate the particles and form agglomerates of suitable sizes and shapes which will be capable of retaining the large or coarse particles in the effective reaction zones until molten.

Reaction mixtures of the invention may be agglomerated in any suitable manner as by means of an inert bonding agent such as sodium silicate or by means of an agent such as an oxidizing agent capable of taking part in reactions with other components. I prefer to form agglomerates by employing oxidizing materials capable of functioning as bonding agents for the particles of the

mixtures. The oxidizing agents may be employed in finely divided condition or they may be employed in the molten state or in the solid state resulting from solidification from the molten state after mixing with the other components. Bonding by means of the oxidizing agents may be of the type effected through the application of high pressures to quantities of the mixtures, or it may be of the type effected by solidification of the oxidizing agents from the molten state in contact with the other components. Contact of the other components of the reaction mixtures with the oxidizing agents while molten causes effective wetting and coating of the other components with the oxidizing agents and provides for more effective reaction upon ignition. When an oxidizing agent is employed in the solid state resulting from solidification from the molten state, it serves as a bonding agent for bonding together in intimate association the other components of the mixture.

The oxidizing agent employed in forming reaction mixtures when fusion is to be carried out should be selected to insure a fusing point below the temperatures at which ignition of the mixture, with resulting reaction, will take place. Oxidizing agents having suitably low fusing or melting temperatures include many of the oxygen-bearing compounds of alkali metals such, for example, as sodium nitrate, sodium chlorate and sodium bichromate. Other oxidizing agents which may be employed in forming the reaction mixtures when incorporation of chromium or manganese in the resulting product is sought, include calcium chromate, sodium chromate and manganese dioxide.

Agglomerates in which the oxidizing material serves as the bonding agent may be produced in any suitable manner. The components which enter into the reactions upon ignition, such as the silicon-containing material and the oxidizing material may be ground together to effect intimate mixing, and the resulting mixture may be heated to a temperature sufficiently high to effect fusion of the oxidizing agent without igniting the reaction mixture. Fusion may be carried out in vessels or pans of the sizes and shapes of the agglomerates sought to be produced, in which case the agglomerates may be permitted to cool and solidify in place, or, fusion may be carried out in a master vessel, and the fused mass may be poured into suitable molds for cooling and solidification. Materials, such as metals and any silicides which do not enter into reactions resulting from ignition may be stirred into the reaction mixtures immediately prior to fusion or after fusion and while the oxidizing material is still molten.

Fused agglomerates of the invention produced by fusing and solidifying the oxidizing materials in contact with the other components provide excellent carriers for materials to be melted by heat developed upon ignition of the mixtures. The agglomerates are very hard and compact and they effectively hold relatively large pieces of metal in the effective reaction zones until they are melted by heat developed in the course of the reactions.

The capacity of the fused agglomerates to retain relatively large pieces or particles of metal in the effective reaction zones makes it possible to employ directly in exothermic mixtures a large proportion of available high-grade scrap iron. The fused agglomerates of the invention also make it possible to employ iron and alloying

metals of the types hereinbefore referred to in the form of relatively inexpensive shot instead of in the form of relatively expensive metal powder.

A considerable amount of scrap iron and steel available as borings, clippings, punchings and the like is in the form of particles which I may and do employ directly in forming reaction mixtures in the form of fused agglomerates.

I utilize the available scrap iron or steel which is in the form of particles too large for effective incorporation directly in fused agglomerates by melting it, converting the molten material into metal shot, and incorporating the resulting metal shot in reaction mixtures in the form of fused agglomerates. In melting such scrap iron and converting it to shot, I may make any desirable or necessary adjustments in its composition.

In carrying out a complete process for altering the composition of foundry iron, a charge may be melted in a cupola as usual. The molten cupola iron may then be treated with iron oxide to reduce silicon, thereafter an exothermic reaction mixture of the invention may be ignited on the surface of the molten metal to deliver to the metal relatively pure molten iron or molten metal containing iron and one or more alloying elements.

The following examples illustrate reaction mixtures and processes of the invention:

Example I

A reaction mixture was produced by grinding together 0.5 pound of ferrosilicon containing 16 percent silicon and 0.63 pound of sodium nitrate and mixing the product thus formed with 1.60 pounds of scrap iron in small pieces. The resulting mixture was heated to a temperature above the fusing point and below the decomposition point of sodium nitrate until the sodium nitrate was fused. The fused mass thus produced was permitted to cool and solidify in the form of an agglomerate or briquette.

The agglomerate thus obtained was placed on the surface of a twenty (20) pound bath of molten iron in a ladle. Reaction was initiated immediately and completed in about one minute.

Analyses of the iron before and after reaction and alteration were as follows:

	Total carbon	Si	Mn
	Percent	Percent	Percent
Before.....	3.17	2.25	0.74
After.....	2.88	2.04	0.60

Example II

A reaction mixture was prepared by fusing 100 pounds of ferrosilicon (15.75% silicon, crushed to minus 100-mesh) with 63 pounds of sodium nitrate and 120 pounds of sheet metal scrap (light steel clippings). When fusion was complete, the fused material was molded into the form of briquettes and allowed to cool and solidify. The briquettes thus obtained were placed on the surface of a two thousand (2,000) pound bath of molten iron in a ladle. Reaction was initiated immediately and completed in eighty (80) seconds.

Analyses of the iron before and after reaction and alteration were as follows:

	C	Si	Mn	S
	Percent	Percent	Percent	Percent
Before.....	3.18	2.34	0.72	0.074
After.....	2.83	2.27	0.60	0.058

Example III

A reaction mixture was prepared by mixing 13 pounds of ferrosilicon containing 90 percent silicon, in the form of particles minus one-quarter ($\frac{1}{4}$ "') inch in size, with 0.7 pound of ferrosilicon containing 75 percent silicon, in the form of particles minus 100-mesh in size and 2.1 pounds of sodium nitrate. The resulting mixture was heated to a temperature between the melting point and the decomposition point of sodium nitrate until the sodium nitrate was fused. The fused material thus formed was cast in the form of briquettes and allowed to cool and solidify. The briquettes thus produced were placed on the surface of a bath of molten iron in a ladle. Reaction was initiated immediately and completed in about one minute. Before reaction and alteration the iron contained 1.17 percent silicon. After reaction and alteration, the iron contained 2.90 percent silicon. The metal was hotter and allowed successful pouring of a larger number of castings than could have been poured with the metal before reaction and alteration.

Example IV

A reaction mixture was prepared by mixing 4.9 pounds of powdered ferrosilicon containing 50 percent silicon with 1.6 pounds of sodium nitrate. The mixture was pressed into the form of briquettes under pressure of 5,000 pounds per square inch. The briquettes were heated to 650° F. and held at temperature for one-half hour to effect fusion of the sodium nitrate. The heated briquettes were permitted to cool and harden.

The briquettes thus obtained were placed on the surface of a 146 pound bath of molten iron in a ladle. Reaction was initiated immediately and completed quickly.

Analyses of the iron before and after reaction and alteration were as follows:

	C	Si	Mn	S	P
	Percent	Percent	Percent	Percent	Percent
Before.....	3.23	1.51	0.66	0.068	0.196
After.....	3.10	2.81	0.64	0.057	0.173

This example illustrates the production and use of reaction mixtures capable of increasing the silicon content of iron. The recovery of silicon was about 95 percent.

In forming reaction mixtures in accordance with the invention, slag-forming materials for fluxing silica produced by oxidation of silicon may be employed or not as desired or required. Usually, when an alkali metal compound such as sodium nitrate or sodium chlorate is employed as the oxidizing material, residual sodium oxide effectively fluxes the silica produced. If however, some sodium oxide is lost by volatilization or if larger slag volumes are preferred in any case, lime or iron oxide or calcium ferrite may be employed as hereinbefore suggested. Lime and iron oxide form fusible silicates of iron and calcium which melt readily under the influence of heat developed during the course of the reactions.

I claim:

1. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to generate sufficient heat to melt the iron of the ferrosilicon.

2. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon intimately associated with and bonded together by means of oxidizing material solidified from the molten state and capable of reacting with the silicon of the ferrosilicon to generate sufficient heat to melt the iron of the ferrosilicon.

3. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon intimately associated with and bonded together by means of sodium nitrate, the silicon of the ferrosilicon and the sodium nitrate being present in amounts and proportions such as to be capable of developing by reaction sufficient heat to melt the iron of the ferrosilicon.

4. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon intimately associated with and bonded together by means of sodium chlorate, the silicon of the ferrosilicon and the sodium chlorate being present in amounts and proportions such as to be capable of developing by reaction sufficient heat to melt the iron of the ferrosilicon.

5. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to develop sufficient heat to melt iron and silicon, the oxidizing material and the silicon being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to melt the iron and the residual silicon of the ferrosilicon.

6. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of calcium oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and generate sufficient heat to melt the iron of the ferrosilicon and calcium silicate formed by reaction of silica produced with calcium oxide of the calcium oxide-bearing material.

7. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of iron oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to promote reduction of the iron of the iron oxide to metallic iron by another portion of the silicon and to melt the iron of the ferrosilicon and the metallic iron produced by reduction of the iron oxide.

8. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon, particles of calcium oxide-bearing material and particles of iron oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable

of developing sufficient heat to promote reduction of the iron oxide to metallic iron with the production of silica by another portion of the silicon and to melt the iron of the ferrosilicon, the metallic iron produced by reduction of the iron oxide and calcium silicate produced by reaction of calcium oxide with silica produced by reaction of the silicon with the oxidizing material and the iron oxide.

9. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of material containing calcium oxide and iron oxide in chemical combination intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to promote reduction of the iron oxide to metallic iron with the production of silica by another portion of the silicon and to melt the iron of the ferrosilicon, the metallic iron produced by reduction of the iron oxide and calcium silicate produced by reaction of calcium oxide with silica produced by reaction of the silicon with the oxidizing material and the iron oxide.

10. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of metallic iron intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to generate sufficient heat to melt the particles of metallic iron and the iron of the ferrosilicon.

11. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of metallic iron intimately associated with and bonded together by means of oxidizing material solidified from the molten state and capable of reacting with the silicon of the ferrosilicon to generate sufficient heat to melt the particles of metallic iron and the iron of the ferrosilicon.

12. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of metallic iron intimately associated with and bonded together by means of sodium nitrate, the silicon of the ferrosilicon and the sodium nitrate being present in amounts and proportions such as to be capable of developing by reaction sufficient heat to melt the particles of metallic iron and the iron of the ferrosilicon.

13. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of metallic iron intimately associated with and bonded together by means of sodium chlorate, the silicon of the ferrosilicon and the sodium chlorate being present in amounts and proportions such as to be capable of developing by reaction sufficient heat to melt the particles of metallic iron and the iron of the ferrosilicon.

14. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon and particles of metallic iron intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to develop sufficient heat to melt iron and silicon, the oxidizing material and the silicon being present

in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to melt the particles of metallic iron and the iron and the residual silicon of the ferrosilicon.

15. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon, particles of metallic iron and particles of calcium oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and generate sufficient heat to melt the particles of metallic iron, the iron of the ferrosilicon and calcium silicate formed by reaction of silica produced with calcium oxide of the calcium oxide-bearing material.

16. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon, particles of metallic iron and particles of iron oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to promote reduction of the iron of the iron oxide to metallic iron by another portion of the silicon and to melt the particles of metallic iron, the iron of the ferrosilicon and the metallic iron produced by reduction of the iron oxide.

17. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon, particles of metallic iron, particles of calcium oxide-bearing material and particles of iron oxide-bearing material intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to promote reduction of the iron oxide to metallic iron with the production of silica by another portion of the silicon and to melt the iron of the ferrosilicon, the particles of metallic iron, the metallic iron produced by reduction of the iron oxide and calcium silicate produced by reaction of calcium oxide with silica produced by reaction of the silicon with the oxidizing material and the iron oxide.

18. A solid agglomerate for use in the production of molten metallic iron comprising particles of ferrosilicon, particles of metallic iron and particles of material containing calcium oxide and iron oxide in chemical combination intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the ferrosilicon to produce silica and develop sufficient heat to melt metallic iron, the oxidizing material, silicon and iron oxide being present in amounts and proportions such that reaction of the oxidizing material with a portion of the silicon is capable of developing sufficient heat to promote reduction of the iron oxide to metallic iron with the production of silica by another portion of the silicon and to melt the iron of the ferrosilicon, the particles of metallic iron, the metallic iron produced by reduction of the iron oxide and calcium silicate pro-

duced by reaction of calcium oxide with silica produced by reaction of the silicon with the oxidizing material and the iron oxide.

19. A solid agglomerate for use in the production of molten metal comprising particles of silicon-containing material and metal shot intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the silicon-containing material to generate sufficient heat to melt the metal shot.

20. A solid agglomerate for use in the production of molten metal comprising particles of silicon-containing material and scrap iron intimately associated with and bonded together by means of oxidizing material capable of reacting with the silicon of the silicon-containing material to generate sufficient heat to melt the scrap iron.

21. The method of melting scrap iron which comprises coating the iron with an exothermic mixture comprising silicon and oxidizing material capable of developing by reaction with silicon a temperature higher than the melting temperature of the scrap iron, and igniting the mixture, the silicon and the oxidizing material being employed in amounts and proportions such as to develop by reaction sufficient heat to melt the coated iron.

22. The method of melting scrap iron in the form of relatively small particles such as borings, clippings, punchings, powder, shot, and the like which comprises coating the iron with an exothermic mixture comprising silicon and oxidizing

material capable of developing by reaction with silicon a temperature higher than the melting temperature of the scrap iron, and igniting the mixture, the silicon and the oxidizing material being employed in amounts and proportions such as to develop by reaction sufficient heat to melt the coated iron.

23. The method of melting scrap iron which comprises converting the iron to the form of shot, coating the iron in such form with an exothermic mixture comprising silicon and oxidizing material capable of developing by reaction with silicon a temperature higher than the melting temperature of the scrap iron, and igniting the mixture, the silicon and the oxidizing material being employed in amounts and proportions such as to develop by reaction sufficient heat to melt the coated iron.

24. The method of producing molten iron for casting purposes which comprises forming a mixture comprising lime, iron oxide, scrap iron, silicon and oxidizing material capable of developing by reaction with silicon a temperature higher than the melting point of iron, and igniting the mixture to initiate a reaction between the silicon and the oxidizing material, the iron oxide, silicon and oxidizing material being employed in amounts and proportions such as to effect reduction of iron of the iron oxide and to develop sufficient heat to melt the reduced iron and the scrap iron.

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