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# UNITED STATES PATENT OFFICE.

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## MANUFACTURE OF FERROUS ALLOYS.

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*To all whom it may concern:*

Be it known that we, HORATIO ARTHUR SKELLEY and ANDREW BRABNER SMITH, subjects of the King of Great Britain, residing at 155 Church Road, Battersea, London, S. W. 11, England, have invented new and useful Improvements in the Manufacture of Ferrous Alloys, of which the following is a specification.

This invention relates to improvements in the manufacture of ferrous alloys composed of iron and relatively small proportions of chromium, with or without carbon and with or without other metals such as tungsten, molybdenum, vanadium, nickel, manganese or titanium.

One object of the invention is the production in a simple and economical manner of chromium-containing alloys of known types, such as "stainless steel" and "high-speed steel." Another object is the production of "rustless iron," i. e. an alloy of iron and chromium containing little or no carbon.

The invention is based upon the discovery that if oxide of iron, in the form of mill scale or the like, be mixed with pulverized silicon or ferrosilicon (containing, say, over 50% Si) and a suitable oxidizing agent containing nitrogen, such as sodium nitrate, reaction may be initiated at a point in the cold or heated mixture as in the well-known alumino-thermic process and if suitable proportions of the ingredients be used the reaction proceeds to completion, a high yield of iron practically free from carbon and silicon resulting. By making suitable additions to the mixture, either initially or during the reaction or after reaction has taken place, alloys of the iron with other metals and with or without carbon may be obtained.

According to this invention, therefore, a ferrous alloy composed of iron and a relatively small proportion of chromium, with or without carbon and with or without other metal or metals, such as tungsten, molybdenum, vanadium, nickel, manganese or titanium, is produced by the silico-thermic reduction of oxide of iron in the form of mill scale, magnetic oxide, ferric oxide or the like, by means of silicon or ferro-silicon (containing, say, over 50% Si) in the presence of a suitable oxidizing agent containing nitrogen, such as sodium nitrate or suitable chromium-yielding and if required other ingredients being added to the mixture either initially or during the reaction or after reaction has taken place.

The chromium and other metal (if any) to be alloyed with the iron may be derived from any convenient source and introduced at any convenient stage in the process. For example, they may be added as metal or alloy in the form of lumps or powder before initiation of the reaction, or in the molten condition at a later stage, or in some cases as the appropriate oxide, to be reduced simultaneously with the oxide of iron. This may be generically referred to as chromiferous material. If it is desired that the resultant alloy contain carbon, the carbon may be added as such to the mixture or may be added as a constitutent of the chromium or ferrochromium used.

The following examples illustrate the invention:—

*I.* "*Stainless steel.*"—Into a crucible is put a mixture of 100 lbs. of mill scale, 22½ lbs. pulverized silicon (or 25 lbs. of ferrosilicon containing 90 per cent Si), 15 lbs. of sodium nitrate and 10½ lbs. of crushed chromium (or 16 lbs. of ferrochromium containing 65 per cent Cr), a quantity of carbon sufficient to ensure the presence of not more than 0.6 per cent thereof in the resulting alloy being introduced, preferably as a constituent of the chromium or ferrochromium. Preferably 7½ lbs. of calcium fluoride are added to enhance the fluidity of the slag produced. Reaction is initiated as in the alumino-thermic process.

*II.* "*High speed steel.*"—Into a crucible is put a mixture of 100 lbs. of mill scale, 28¼ lbs. of pulverized silicon (or 31½ lbs. of ferrosilicon containing 90 per cent Si), 15 lbs. of sodium nitrate, and 21½ lbs. of tungsten ore free from tin and other objectionable impurities and containing 70 per cent of $WO_3$ and 16 per cent of FeO. Preferably 7½ lbs. of calcium fluoride are added to enhance the fluidity of the slag produced. Reaction is initiated and 3½ lbs. of ferrochromium (containing 65 per cent Cr and 6 per cent carbon) and 6 lbs. ferrovanadium (30 per cent V) are then added to the molten reduced metal. In this example the tungsten in the resulting alloy is produced by the silico-thermic reduction of the tungsten oxide in the ore.

*III.* "*Rustless iron.*"—The procedure is the same as in the first example above except that the materials employed contain little or no carbon. The invention is particularly suitable for the production of this alloy, which possesses properties of considerable industrial value.

What we claim is:—

1. The manufacture of an alloy containing iron and chromium by the silico-thermic reduction of iron oxide and chromiferous material in the presence of an oxidizing agent containing nitrogen.

2. The manufacture of an alloy containing iron and chromium by the silico-thermic reduction of iron oxide and chromiferous material in the presence of a nitrate oxidizing agent.

3. The manufacture of an alloy containing iron and chromium by the silico-thermic reduction of iron oxide and chromiferous material in the presence of carbon and an oxidizing agent containing nitrogen.

4. The manufacture of an alloy containing iron and chromium by the silico-thermic reduction of iron oxide and chromiferous material in the presence of carbon and a nitrate oxidizing agent.

5. The manufacture of rustless iron by silico-thermic reaction in a mixture of 100 parts of mill scale, 22½ parts silicon, 15 parts sodium nitrate and 10½ parts chromium.

In testimony that we claim the foregoing as our invention we have signed our names this 17th day of May, 1922.

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