Patented Nov. 19, 1940

2,221,781

UNITED STATES PATENT OFFICE

2,221,781

ADDITION AGENT AND ITS USE IN THE TREATMENT OF IRON AND STEEL

James H. Critchett, Douglaston, and Walter Crafts, Niagara Falls, N. Y., assignors to Electro Metallurgical Company, a corporation of West Virginia

No Drawing. Application April 14, 1938, Serial No. 201,931

7 Claims. (Cl. 75—58)

The invention relates to the treatment of molten steel to promote a fine grain structure and freedom from deleterious impurities.

During manufacture, steels become contaminated with certain oxides and occluded gases, which, if not substantially removed or rendered innocuous, detrimentally affect the soundness and physical properties of the finished steel. To overcome the deleterious effects of such impurities, an addition of ferrosilicon or ferromanganese, or both, as deoxidizers, is usually made to the steel shortly before casting into ingots or other shapes. For further deoxidation, and to provide an inherently fine-grained steel having inhibited grain growth tendencies at elevated temperatures, a later addition of aluminum is often made to the molten steel.

Aluminum additions, in the amounts, for the purposes, and in the manner described above, tend to produce a steel containing deleterious types and quantities of non-metallic inclusions. It has been proposed to substitute for the aluminum other agents, such as vanadium, zirconium, or titanium, but none of these elements is entirely satisfactory. Vanadium is usually too expensive to add in an amount sufficient to produce the desired results, and zirconium and titanium as heretofore used tend to produce a steel containing numerous objectionable non-metallic impurities.

According to the present invention, a steel that is substantially free from deleterious, gaseous or solid non-metallic impurities and that has improved mechanical properties (including improved impact strength) and excellent fine grain characteristics is produced by adding to the steel while it is molten in the ladle or otherwise shortly before casting, an addition agent containing 25% to 85% (preferably 35% to 55%) of silicon, remainder iron and at least two elements selected from the following three groups: (1) beryllium, magnesium, calcium, barium, strontium, boron, and aluminum; (2) titanium, zirconium, cerium, hafnium, and thorium; (3) vanadium, columbium, and tantalum, elements from at least two of said groups being present each in an amount at least 3%. Iron is present as an impurity or diluent unavoidably introduced in producing an economical and commercially practicable material, and should not exceed about 65%. The total amount of the elements selected from the groups herein described is preferably at least 10% but not over 60% of the composition of the addition agent. If the number of elements in said mixture is only two, said total amount should preferably not exceed 25% of the composition of the addition agent, and if such number is more than two, said total amount preferably exceeds 25% by not more than 5% for each of said elements above two. A preferred addition agent composition contains 45% to 65% silicon, 5% to 15% zirconium, 5% to 15% vanadium, and 5% to 15% aluminum, the remainder iron.

The constituents of the addition agent are preferably prealloyed in the form of a master alloy; but they may be unalloyed or only partially alloyed, and used in the form of a briquet of comminuted material. Also, some of the constituents thereof may suitably be in the form of easily reducible or decomposable compounds such as nitrides, nitrates or mixtures thereof. It is essential, however, that the constituents be closely associated, because successive additions of the several constituents separately to the steel do not yield the improved results of the invention.

In general, the more complex the addition agent, that is, the greater the number of deoxidizing ingredients, selected from the above groups, the better the results.

Alloys having substantially the compositions indicated in the following table are typical of those that have been used successfully in practicing the invention.

Percent Si	Percent V	Percent Zr	Percent Al	Percent Fe
50	18	8	None	Remainder.
50	6	15	None	Remainder.
50	7.5	12.5	None	Remainder.
50	7.5	7.5	7.5	Remainder.

In practicing the process of the invention, we prefer to add to the molten steel being treated a sufficient amount of the addition agent of the invention that the silicon content of the steel is increased by about 0.25%. The deoxidizing or grain refining power may be controlled and varied by adding more or less than enough material to increase the silicon content of the steels by about 0.25%, or alternatively, the concentration of silicon relative to the other constituents of the addition agent may be varied. If less grain refinement is required, part of the silicon required for deoxidizing may be added as the agent of the invention and part as ordinary ferrosilicon, and if more grain refinement is required, the action of the addition agent may be supplemented by an addition of aluminum or other grain refiner.

The desired composition may be added to the steel in any well known manner, for example, in the furnace, in the ladle, or in the molten stream during pouring. When adding the addition agent to the steel either in the ladle or in the molten stream, an agent containing less than about 50% iron should ordinarily be used in order to minimize the chilling effect of the iron. If the agent is added to the steel in the furnace, the iron content of the agent may be greater than 50%.

By proper selection of elements, a grain size of No. 6 or No. 7 may readily be procured in steels treated acording to a method of the invention. Throughout the present specification, "grain size" refers to austenitic or inherent grain size determined by the McQuaid-Ehn carburizing test conducted at a temperature of 925° C. for 8 hours, as defined by the A. S. T. M. specification E 19–33. The degree of grain refinement or deoxidation of the steel per unit of addition agent added will vary, not only with the combination of elements selected, but also with the type of steel being treated, so that the total amount of agent to be added to the steel for best results must be determined by trial. Ordinarily, this total amount of agent will be less than 5%, and most frequently less than 1%.

While the addition agents of this invention are especially useful in the treatment of steels which are to be hot worked, the invention is also applicable to the treatment of steels which are to be employed as castings. Used for the latter purpose, it has been found that, in many instances, the characteristics of the casting may be improved if the material of the invention is added in an amount which is sufficient to deoxidize the metal, yet is insufficient to develop harmful inclusions.

Steels treated according to the invention are sound, substantially free from excessive nonmetallic inclusions, and possess improved ductility and shock resistance. Further, the few inclusions distributed throughout such steels are more uniform than diverse, that is, the majority of the inclusions which usually accompany any deoxidizing treatment that produces small grain size are not noticeable in the steels deoxidized in accordance with the invention until a higher degree of grain refinement is attained than that attainable by the addition of aluminum alone.

We claim:

1. A method of treating molten ferrous metal which comprises adding to the molten ferrous metal a grain-refining amount less than 1% of an addition agent containing 25% to 55% silicon; 3% to 20% of at least one element selected from the group beryllium, magnesium, calcium, barium, strontium, boron, and aluminum; 3% to 20% of at least one element selected from the group titanium, zirconium, cerium, hafnium, and thorium; 3% to 20% of at least one element selected from the group vanadium, columbium, and tantalum; and the remainder iron.

2. A method of deoxidizing molten iron or steel which comprises adding to the molten iron or steel a grain-refining amount less than 1% of an addition agent containing 35% to 55% silicon, 3% to 20% aluminum, 3% to 20% zirconium, 3% to 20% vanadium, and the remainder iron.

3. A method of deoxidizing molten iron or steel which comprises adding to the molten iron or steel a grain-refining amount less than 1% of an addition agent containing 35% to 55% silicon, 5% to 15% aluminum, 5% to 15% zirconium, 5% to 15% vanadium, the remainder iron.

4. A composition of matter for use as an addition agent for treating molten ferrous metal, containing 35% to 55% silicon; 3% to 20% of at least one element selected from the group beryllium, magnesium, calcium, barium, strontium, boron, and aluminum; 3% to 20% of at least one element selected from the group titanium, zirconium, cerium, hafnium, and thorium; 3% to 20% of at least one element selected from the group vanadium, columbium, and tantalum; and the remainder iron.

5. An addition agent for deoxidizing molten iron or steel, containing 35% to 55% silicon; 3% to 20% aluminum, 3% to 20% zirconium, 3% to 20% vanadium, the remainder iron.

6. An addition agent for deoxidizing molten iron or steel, containing 35% to 55% silicon; 5% to 15% aluminum, 5% to 15% zirconium, 5% to 15% vanadium, the remainder iron.

7. A composition of matter for use as an addition agent for treating molten ferrous metal, containing about 25 to 55% silicon; 3 to 20% aluminum; 3 to 20% of at least one element selected from the group titanium and zirconium; 3 to 20% of at least one element selected from the group vanadium and columbium; and the remainder iron.

JAMES H. CRITCHETT.
WALTER CRAFTS.