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STEEL.

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To all whom it may concern:

Be it known that I, KARL W. ZIMMERSCHIED, a citizen of the United States, and a resident of New Rochelle, county of Westchester, and State of New York, have invented certain new and useful Improvements in Steels, of which the following is a full, clear, concise, and exact description, such as will enable others skilled in the art to which the invention relates to make and use the same.

In the manufacture of chrome-vanadium steel, which combines both hardness and toughness to an unusual degree, it is generally maintained that the vanadium has a two-fold effect; 1st, that it is a strong deoxidizing agent and removes oxygen and other deleterious elements more thoroughly than manganese, silicon or other elements that are ordinarily added for this purpose in making open hearth steel; 2nd, that the vanadium which still remains in the metallic state after the purging action alloys with the metallic steel with the effect of—(*a*), increasing the elastic limit and tensile strength; (*b*), increasing the ductility; (*c*), increasing the resistance to failure through the application of alternate or repeated stresses; and (*d*), inhibiting grain growth at high temperature. The same general comments apply to steels wherein the vanadium is replaced to a greater or less degree by other elements of the vanadium type which have a strong affinity for oxygen and in some instances for nitrogen also, such as molybdenum, magnesium, aluminum, titanium and uranium, singly or in various combinations one with another, it being understood that the element which has the predominating effect of increasing the hardness, raising the elastic limit and tensile strength, and, in general, increasing the susceptibility to heat treatment, in each instance, is chromium.

Heretofore such steels have been produced principally in the open hearth furnace, which, due to the method of firing and the general form of the furnace, is inherently oxidizing and therefore incapable of refining steel beyond the point of removing such elements as can be absorbed in a slag which is strongly oxidizing, whether acid or basic in nature, depending on the type of lining; by this process of manufacture, it has not been possible, therefore, to remove elements which require a reducing condition in the slag for their combination.

Considerable amounts of steel containing chromium in combination with the other elements mentioned above have also been made in the electric furnace, where conditions are normally of a strong reducing nature, but, in my opinion, the addition of these strongly reducing elements to steel which is made under conditions that are themselves strongly reducing, represents a duplication of effect. To the best of my knowledge, I am the first to recognize that the reducing conditions which are normally present when steel is made in the electric furnace either may be utilized to produce a chrome steel which is substantially equal in quality to a steel which has vanadium and elements of like nature added, or that these reducing conditions can be so intensified or modified as to endow the steel with substantially the same properties as if vanadium or like elements had been added.

The primary object of the present invention is therefore to produce, by commercial methods and without the use of added contents of vanadium or other corresponding purging element or elements, steels having the desirable properties of chrome-vanadium and similar steels, and thereby to insure a supply of steels especially useful for gears, shafts, and other parts requiring both hardness and toughness.

This I accomplish by making chrome steel, practically normal in all respects, by removing the oxygen and other deleterious elements in the electric furnace. In the preferred practice, the treatment extends from the time the steel is heated to fluidity, to the time the deleterious elements have been removed to an extent such as to render them substantially unobjectionable, but it may be applied to steels as manufactured in the open hearth type of furnace in lieu of the treatment of such steels by vanadium or the like, that is, by subsequently treating steel which has been melted in the open hearth

furnace, in the electric furnace, regardless of whether the chromium is added in the electric or in the open hearth furnace. By proceeding in this manner, those elements which are eliminated in the production of chrome-vanadium steel, together with a large proportion of the phosphorus and sulphur, which require reducing conditions for combination with the slag, may be removed; likewise, oxides of iron and manganese, which make the steel brittle and undependable, are reduced to the metallic form or combined with slag for the most part, and thereby rendered innocuous.

The actual analysis or mix of the steel is of course subject to considerable variation, and the invention is to be regarded as applying generally to chromium steels where the use of vanadium and like elements is eliminated, and substantially the same results attained by exposure to the reducing conditions present in the electric furnace. The following may be regarded as a typical analysis:

Carbon .50, manganese .70, phosphorus .010, sulphur .025, chromium 1.00. In other instances the carbon and chromium might appear, say as .20 and .40, respectively, or say .90 to 1.10 carbon and 1.15 chromium, or any combination, between these limits, or even in some instances outside these limits.

In the manufacture of chrome-vanadium steel, for reasons well known in the art, the vanadium is added in the ladle, where the conditions are not of a reducing nature, consequently the time during which the steel is exposed to reaction with the vanadium or corresponding element or elements is comparatively short, due to the cooling of the metal in the ladle, and the heats made in this manner are lacking in uniformity. On the other hand, when the steel is made in accordance with the present invention, ample time is available for the de-oxidizing process, which is therefore under more complete control, inasmuch as the slag may be sampled from time to time and the extent of de-oxidation ascertained with certainty. Hence the physical properties of the finished steel can be duplicated in successive heats, and very uniform results obtained. The same consideration permits a more careful selection of the pouring temperature, with resulting reduction in croppage; and it has also proven effective in reducing the phosphorous and sulphur content below that ordinarily present in chrome-vanadium steel.

It will be understood, therefore, that the invention results in a new type of chrome steels having, in addition to the usual hard properties of chrome steels made in the open hearth process, a high degree of toughness and dependability, as well as other desirable properties resulting from the elimination of those elements and impurities which remain in ordinary chrome steels, and produces a steel in all respects equal or superior to chrome-vanadium steel in actual or potential physical properties (i. e. after or before heat treatment) and uniformity or dependability.

I claim:

1. That improvement in the art of manufacturing commercial steels having the general properties of ordinary chrome-vanadium steels without the use of a vanadium-type reducing element which consists in subjecting normal chrome steel to the action of the ordinary steel-making materials in an electric furnace to an extent sufficient to remove the objectionable oxides and other deleterious elements.

2. That improvement in the art of manufacturing alloys steels which consists in utilizing the reducing conditions in the electric furnace to replace the addition of vanadium and like elements to remove the deleterious substances and produce a steel having substantially the same properties as if said elements had been added.

3. That improvement in the art of manufacturing commercial steels which consists in subjecting normal chrome steels to strongly reducing conditions present in an electric furnace for considerable periods of time and to an extent sufficient to endow the resulting steels with properties substantially the same as those of ordinary chrome-vanadium steels.

4. An electrically reduced normal chrome steel having no added content of vanadium or vanadium-like element and having not more than substantially .01 per cent phosphorous content by weight and not more than substantially .025 per cent sulphur content by weight, said steel having the toughness and hardness of ordinary chrome-vanadium steel.

5. The process of producing chrome-vanadium type steels, free from vanadium and vanadium-like elements as an added content, which consists in melting the ingredients of normal chrome steels and thereafter subjecting the molten metal, for considerable periods of time, to strongly reducing conditions in an electric furnace.

6. The process of toughening normal chrome steel, free from vanadium-type metals as an added content, which consists in subjecting said steel to strongly reducing conditions of an electric furnace for considerable periods of time and until the toughness of said steel is substantially that of ordinary chrome-vanadium steel.

7. Chrome steel, having no added content of vanadium or vanadium-like element, and having sulphur and phosphorous contents not greater than those of ordinary chrome-vanadium steel, and having the toughness and hardness of ordinary chrome-vanadium steel.

8. Chrome steel having no added content of vanadium or vanadium-like element, and not more than approximately .01 per cent phosphorous content by weight, and having the toughness and hardness of ordinary chrome-vanadium steel.

9. Chrome steel having no added content of vanadium or vanadium-like element, and not more than approximately .025% sulphur by weight, and having the hardness and toughness of ordinary chrome-vanadium steel.

In testimony whereof I affix my signature.

KARL W. ZIMMERSCHIED.