Patented Oct. 8, 1946

2,409,016

UNITED STATES PATENT OFFICE

2,409,016

SHOCK-RESISTANT SILICON STEEL HARDENED WITH TITANIUM

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No Drawing. Application October 19, 1942, Serial No. 462,508

6 Claims. (Cl. 75—123)

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My invention relates to steel alloys, and particularly, though not exclusively, to steel alloys used in making percussion tools.

The object of the invention is to provide a steel alloy in which high resistance to fatigue and crystallization is obtained in conjunction with increased tensile strength, hardness, and toughness.

Another object is to provide a self-hardening steel which possesses the characteristics mentioned.

With these and other objects in view, the invention consists in a steel alloy of the composition described below, and particularly defined in the appended claims.

The ingredients of my improved alloy, and their proportions by weight in the finished product, are substantially as follows:

	Per cent
Carbon	0.40 to 1.00
Manganese	0.35 to 2.50
Silicon	0.80 to 2.75
Molybdenum	0.15 to 2.90
Titanium	0.10 to 0.90
Iron	Remainder

The combined molybdenum and titanium ranges substantially from 0.25% to 3.80%. The phosphorus and sulphur impurities are held to normal values.

The steel alloy will preferably be produced in an electric furnace, and it will be understood that traces of other usual elements may be present in the product, depending upon the composition of the melts that were previously made in the melting furnace. For example, immediately prior to making a batch of my steel, the steel producer may have been using the furnace for the production of stainless steel, or high chromium steel, in which case the lining of the furnace may be contaminated with chromium, or nickel, or copper, or tungsten, or other alloys or combinations, and if the furnace is not thoroughly "washed" out by the melting of one or more heats of plain carbon steels, certain inclusions, not desired, but permissible, will be found in my steel. In a typical case a heat of my steel picked up chromium in the amount of from 0.06% to 0.07%, and, while this chromium was not desired, it was permissible. The same may be said of other alloys that will ordinarily be picked up in the melting furnace.

The carbon, manganese, and silicon will be added to the mix in the furnace, and the molybdenum and titanium additions preferably, although not necessarily, will be made in the ladle,

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in which case the temperature of the mix in the ladle will be increased approximately two hundred degrees above normal pouring temperature.

Ordinarily, ferro-compounds of silicon, manganese, molybdenum, and titanium are best to use in the mix.

In the manufacture of titanium steels hitherto, substantial quantities of the added titanium have been lost, ordinarily as much as 25%. (See page 21 of the book entitled "Titanium and Its Use in Steel," copyrighted in the year 1940 by The Titanium Alloy Manufacturing Company of Niagara Falls, New York. See also page 951 of The Making, Shaping and Treating of Steel, Fifth edition, by The Carnegie-Illinois Steel Corporation, published in Pittsburgh, Pennsylvania, 1940.) I have discovered that, if the silicon content of the molten bath of metal is maintained greater than, and preferably from one and one quarter to three or more times as great as, the titanium content, the titanium will not be lost, but will substantially all persist as an alloying component of the finished steel.

It has been known in the art that both titanium and silicon may be used as deoxidizers in the production of steel, but so far as I am aware, no one has heretofore realized that, in the case of a titanium steel, particularly a titanium steel containing molybdenum, silicon may be used as an effective agent to prevent the loss of any substantial portion of the titanium introduced to the mix.

It is believed that in the improved steel alloy of my composition a molybdenum-titanium carbide is formed, this being indicated by the fact that from 12% to 14% of the carbon originally added to the melt is absorbed. The steel is of fine grain structure, great density and toughness, and exceedingly high tensile strength.

Titanium when present in steel, particularly in amounts above 0.10%, is known as an inhibitor of the hardenability of the steel, and it is remarkable that the titanium steel of my invention possesses high self-hardening qualities. When forged and cooled in the atmosphere, the steel develops a hardness of from 60 C to 62 C, Rockwell. The steel may also be heat treated, by raising it to a temperature of 1600° F. and cooling it in water or in oil, and it may be used with or without tempering, depending upon the particular service. The steel possesses high red-hardness. It has high resistance to fatigue and crystallization and will not fail under shock, and (by virtue of its high red-hardness) it is enduring under conditions of service in which heat is generated by

friction and abrasion. Possessing such qualities as these my steel is excellent for use in cutter bits of mining machinery, pneumatic chisels for chipping and cutting hot or cold metal, cold cutters, heading dies, forging dies, bushings for pneumatic hammers, shear blades for hot or cold work, rivet bull dies for either pneumatic or hydraulic machines, battering mauls and sledges, and hollow and solid drills. And it will be understood that many other fields lie open to the use of such steel.

The application for these Letters Patent consisted in a continuation in part of application Serial No. 407,439, filed by me on August 19, 1941, for Titanium steel and method of production.

Many variations in the proportions of the alloying elements may be made without departing from the invention, as defined in the appended claims.

I claim as my invention:

1. A shock-enduring steel alloy of high hardenability having substantially the composition: carbon, 0.40–1.00%; manganese, 0.35–2.50%; silicon, 0.80–2.75%; molybdenum, 0.15–2.90%; titanium, 0.10–0.90%; the silicon being in excess of the titanium, and the remainder substantially iron.

2. A shock-enduring steel alloy of high hardenability having substantially the composition: carbon, 0.40–1.00%; manganese, 0.35–2.50%; silicon, 0.80–2.75%; molybdenum, 0.15–2.90%; titanium, 0.10–0.90%; the silicon being in excess of the titanium, and the remainder substantially iron, the titanium content of the steel alloy comprising almost all of the titanium introduced to the mix.

3. A shock-enduring steel alloy of high hardenability containing, in addition to its essential ferrous content, carbon, manganese, silicon, molybdenum, and titanium as the principal alloying ingredients, the combined molybdenum and titanium content ranging substantially from 0.25% to 3.80% and including at least 0.10% titanium and 0.15% molybdenum, and the silicon being in excess of the titanium.

4. A shock-enduring steel alloy of high hardenability containing, in addition to its essential ferrous content, carbon, manganese, silicon, molybdenum, and titanium as the only alloying ingredients, the combined modybdenum and titanium content ranging substantially from 0.25% to 3.80% and including at least 0.15% molybdenum and 0.10% titanium, the silicon ranging between 0.80 and 2.75%.

5. A shock-enduring steel alloy of high hardenability containing, in addition to its essential ferrous content, carbon, silicon, molybdenum, and titanium as the only alloying ingredients, the combined molybdenum and titanium content ranging substantially from 0.25% to 3.80% and including at least 0.10% titanium and at least 0.15% molybdenum, the silicon content being at least one and one-quarter times the titanium content.

6. A shock-enduring steel alloy of high hardenability containing, in addition to its essential ferrous content, carbon, silicon, molybdenum and titanium, these being the only alloying ingredients, the combined molybdenum and titanium content ranging substantially from 0.25% to 3.80% and including at least 0.10% titanium and at least 0.15% molybdenum, and the silicon content being at least one and one-quarter times the titanium content, the titanium content of the steel alloy comprising almost all of the titanium introduced to the mix.

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