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# UNITED STATES PATENT OFFICE

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## STEELS AND ELECTRICAL RESISTANCE ELEMENTS

Russell Franks, Niagara Falls, N. Y., assignor to Electro Metallurgical Company, a corporation of West Virginia

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6 Claims. (Cl. 75—126)

This invention relates to alloy steels containing chromium and aluminum, and also to electrical resistance elements composed of such steels.

Steels containing 10% to 30% chromium and aluminum in an amount below 10% have been used for various purposes, notably to resist oxidation and scaling at elevated temperatures,—electrical resistance heating elements for instance. It has also been proposed to improve the properties of such steels by the addition of one or more of the elements titanium, zirconium, cerium, thorium, vanadium, columbium, and tantalum, that form relatively stable carbides and, through this or other characteristics, improve the resistance of the steels to oxidation. Additions of these elements in amounts up to 5% or more have been proposed.

I have found that the addition of nitrogen in a relatively small amount between 0.05% and 0.5% considerably improves the resistance of the steels just described to oxidation and scaling at elevated temperatures. Furthermore, such improvement is accomplished by an improvement in the toughness of the material, and the latter improvement favorably affects the ability of the steel to withstand extensive hot and cold forming operations in the manufacture of rods, bars, strip, and wire for electrical resistance heating elements.

The invention accordingly comprises an alloy steel resistant to oxidation and scaling at elevated temperatures, and an electrical resistance heating element in the form of a rod, bar, strip, or wire composed of such steel. The steel and heating element of the invention are composed of a ferritic chromium-aluminum steel containing in addition to iron and not over 1% each of manganese and silicon, carbon in an amount not exceeding 0.5%, between 10% and 30% chromium, a substantial amount not exceeding 10% of aluminum, and 0.05% to 0.5% nitrogen uniformly distributed throughout the steel. One or more of the elements titanium, zirconium, cerium, thorium, vanadium, columbium, and tantalum may also be added in an amount not exceeding a total of 5%, and preferably in a total amount between 0.2% and 2%. It is preferred that the chromium content be between 16% and 25%, the aluminum content be between 2% and 6%, the carbon content be less than 0.2%, and the nitrogen content be between 0.08% and 0.3%.

The improved resistance to oxidation imparted by the addition of nitrogen is indicated by data secured in comparative tests. Representative of such data are those appearing in the following table. Except for steels 6 and 8, the loss in weight was determined after the surface scale had been removed from each sample of steel.

| Steel No. | Composition (remainder iron) | | | | | Loss or gain in weight after 48 hrs. at 1150° C. |
|---|---|---|---|---|---|---|
| | Percent Cr | Percent Al | Percent C | Percent Cb | Percent N | |
| 1 | 15 | 3 | 0.16 | None | Under 0.05 | 21% loss. |
| 2 | 15 | 3 | 0.12 | None | 0.10 | 4.8% loss. |
| 3 | 15.4 | 5.7 | 0.15 | 0.54 | Under 0.05 | 1.7% loss. |
| 4 | 15.5 | 6.1 | 0.16 | 0.5 | 0.10 | 0.31% loss. |
| 5 | 25 | 3 | 0.13 | None | Under 0.05 | 0.04% loss. |
| 6 | 25 | 3 | 0.15 | None | 0.20 | 0.41% gain. |
| 7 | 25 | 3 | 0.17 | 0.5 | Under 0.05 | 0.008% loss. |
| 8 | 25 | 3 | 0.31 | 0.5 | 0.10 | 0.04% gain. |

The nitrogen favorably affects the character of the oxide scale formed on the surface of the metal, making the scale more firmly adherent to the metal and, probably, more dense and less permeable to oxygen. The scale formed on steels 1, 3, 5, and 7, for instance was relatively looser than that formed on the corresponding nitrogen-containing steels. The scale formed on steels 6 and 8 could not be removed without at the same time removing metal, which accounts for the gains in weight of the samples.

I claim:

1. Alloy ferritic steel resistant to oxidation and scaling at elevated temperatures and comprising 10% to 30% chromium, aluminum in an amount between about 2% and 10%, carbon in an amount not exceeding 0.5%, nitrogen in an amount between 0.05% and 0.5%, and the remainder principally iron.

2. Alloy ferritic steel as defined in claim 1, containing a substantial amount not over 5% of an addition chosen from the group consisting of the elements titanium, zirconium, cerium, thorium, vanadium, columbium, tantalum, and mixtures of at least two of such elements.

3. Alloy ferritic steel resistant to oxidation and scaling at elevated temperatures and comprising 16% to 25% chromium; aluminum in an amount between about 2% and 6%; carbon in an amount not exceeding 0.2%; nitrogen in an amount between 0.08% and 0.3%; manganese and silicon in amounts not exceeding 1% each; from 0.2% to 2% of an addition chosen from the group consisting of the elements titanium, zirconium, cerium, thorium, vanadium, columbium, tantalum, and mixtures of at least two of such elements; and the remainder iron.

4. An electrical resistance heating element composed of the alloy defined in claim 1.

5. An electrical resistance heating element composed of the alloy defined in claim 2.

6. An electrical resistance heating element in the form of a rod, bar, strip, wire, or the like, and composed of the alloy defined in claim 3.

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CERTIFICATE OF CORRECTION.

Patent No. 2,191,790. February 27, 1940.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 23, for the word "accomplished" read accompanied; and that the sand Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of April, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)