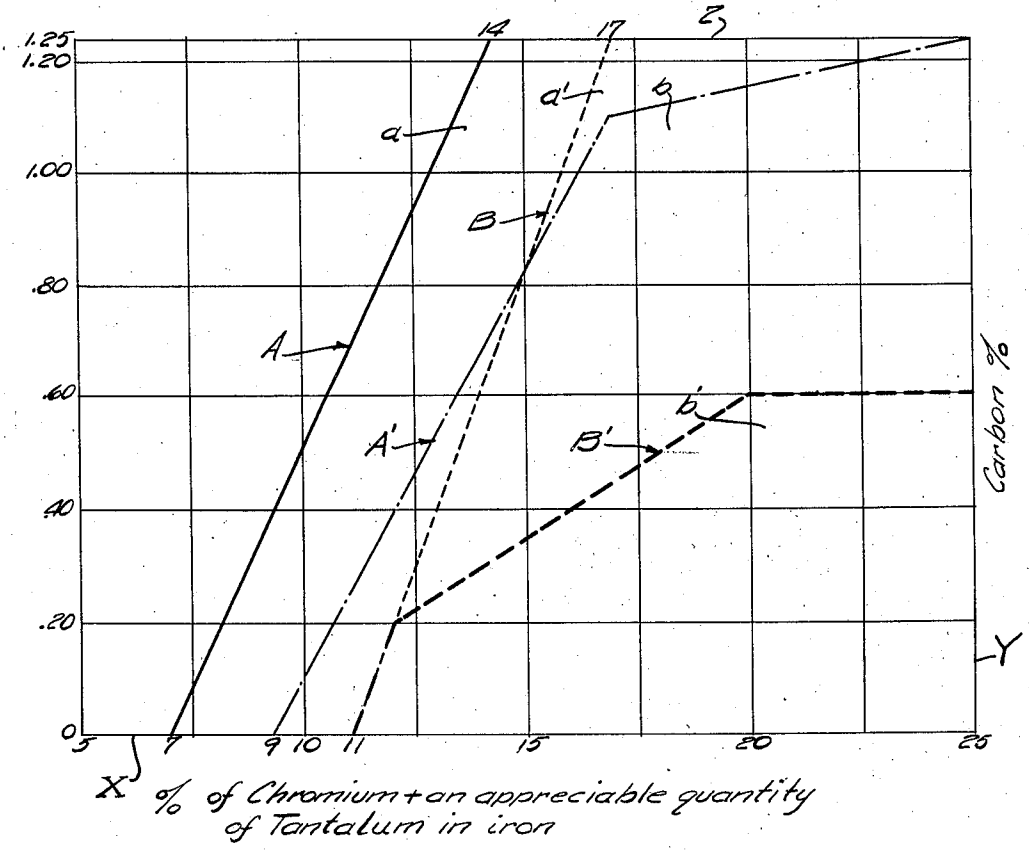
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RUST, ACID, AND HEAT RESISTING FERROUS ALLOY CONTAINING CHROMIUM AND TANTALUM

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RUST, ACID, AND HEAT RESISTING FERROUS ALLOY CONTAINING CHROMIUM AND TANTALUM.

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My invention relates to ferrous alloys containing iron, chromium and tantalum, with or without carbon. Manganese and silicon together or separately improve the alloy. For instance where the alloy is capable of being hardened manganese adds to the hardness obtainable; silicon adds to the scale resistance property of the alloy when subjected to high temperatures. Phosphorus and sulphur should be kept low.

My alloy is very resistant to staining by food acids and vinegar, such as are encountered in household or hotel service, it is very resistant to nitric acid, but not very resistant to sulphuric acid, hydrochloric acid, or hydrofluoric acid.

Tantalum has the desirable property of resisting mineral acids, probably due to passivity. Alloys of tantalum and iron do not seem to have similar properties where the iron is in much the greater proportion.

Tantalum, chromium and iron alloys are very resistant to rust and weak acids, due I believe to a great readiness to become passive.

Tantalum imparts to chromium and iron great strength and toughness, particularly at high temperatures.

Alloys of chromium and iron containing about 16% of chromium when annealed have a low proportional limit. The addition of 2% of tantalum to such alloys raises the proportional limit by almost 100%, thereby providing an alloy in the class of those having the strength of structural steel.

Very small quantities of tantalum have a noticeable effect on chromium and iron alloys, and also upon chromium and steel. I prefer to use tantalum up to about 10%; for most purposes tantalum up to 5% appears to be desirable.

Tantalum improves the hot working properties of the alloy, particularly when the tantalum is about 2%. When the tantalum content is carried up to 10% the hot working properties of my alloy are not markedly improved by the additional tantalum, and if with such high tantalum the chromium content of the alloy is towards the high limit, the alloy seems to have too great a quantity of alloying constituents with the iron for very ready hot working. This condition is more noticeable as the carbon is raised towards the upper limit.

Carbon increases the physical properties of the alloy in the annealed or in the heat treated condition, such as hardened, or hardened and drawn. Carbon has the effect of decreasing the rust resisting, acid resisting and heat resisting properties of the alloy, and should, therefore, be kept low, unless the carbon is required for hardening or strengthening purposes.

With increase of the chromium content there is a corresponding increase in the quantity of carbon required to produce substantial hardness on being quenched from high temperatures.

If the silicon content is raised to 1% or 2% and the chromium content is about 14% to 16% and with the carbon low (under .30%) the alloy is apt to lack shock strength in the annealed condition, due in part to the high chromium content. When, however, 1% to 3% of tantalum is added to such an alloy there is a marked increase in shock resistance. The lower the carbon the more noticeable this becomes.

My alloy contains, besides tantalum, chromium 7% to 25%, carbon .0 to 1.25% and with or without high melting point elements. Where added resistance to scaling at high temperatures is required, silicon up to about 4.5% is used. Such high silicon, however, is not claimed herein, as the alloy comprising 1% or more of silicon will be covered in a separate application. In the present case, while silicon is not essential, same may be made use of as a normal constituent of steel and up to about 1%.

The single figure of the accompanying drawing shows the approximate limits in accordance with my invention of carbon and chromium content in iron with an appreciable addition of tantalum. Line A defines substantially the approximate upper limit of carbon and chromium with minimum tantalum that can be used in iron to produce a stain free and rust resisting alloy when hardened from high temperatures, often higher than is necessary to produce hardness. I prefer to harden by quenching in oil from about 1900° F. This temperature is over the carbon transformation point, and insures a rapid and thorough solution of the carbides. There will always be free carbide in the hardened alloy, but less when hardened from such high temperatures than from lower temperatures closer to or only slightly over the upper critical point.

It is best practice not to approach too close-

ly to the limit line A, but to keep the carbon and chromium somewhat under the maximum possible limiting figures and with this in view I have defined by line A′ the approximate upper limit of carbon and chromium with minimum tantalum, that I prefer to use for purposes where hardening or hardening and tempering are of importance. Within the field to the right of and below said line A′ no difficulty is experienced in obtaining the desired stain free, rust resisting and heat resisting qualities upon suitably heating and cooling the alloy.

Line B defines substantially the upper limit of carbon and chromium with appreciable quantity of tantalum that can be employed within my limits, in producing an alloy which will be stain free and substantially rustless in the annealed condition. The higher the chromium and tantalum with a given carbon the greater are the described properties and I have substantially defined by line B′ the approximate upper limit of carbon and chromium with an appreciable quantity of tantalum that I desire to use when the alloy is to be used in the soft or annealed condition. The auxiliary or subordinate limits A′ and B′ are preferably made use of in practice for melting specifications with possible variation up to lines A and B in the case of heat treated and annealed products respectively. For convenience of reference, I have designated the area AXYZ as *a*; area A′XYZ as *a′*; area BXY as *b*; and area B′XY as *b′*.

I prefer to keep the carbon under .20% for all purposes when used in the annealed condition, and below .10% carbon if maximum rust and acid and heat resisting properties are essential.

I restrict my upper limit of chromium to about 25% because beyond this quantity of chromium the rust, acid, and heat resisting properties are not sufficiently enhanced to justify the use of additional quantities of chromium.

The use of less than 7% of chromium requires additional elements to impart to the alloy rust, acid and heat resisting properties that are of importance as far as this invention is concerned. I have, therefore, restricted my minimum chromium content to about 7%.

When the carbon content is raised above the limit shown by line A on the drawing the alloy either is not sufficiently acid, rust and heat resisting for the purpose of this invention, or the alloy becomes too hard for ready working.

Naturally these limits are not hard and fast lines of demarcation, but are more in the nature of zones.

My alloy in particularly useful in the hardened and tempered condition for tools, cutlery, balls, hardened or hardened and tempered parts, valves and valve seats, roofing cooking utensils, pans, castings, tubes, wire, forgings, and all purposes that require machining or working in any way.

The surface of the alloy should be sand blasted, pickeled, or cleaned if the alloy surface is desired to remain clean, and is to resist rust and corrosion by acid or water vapor, in the form of steam, for example. The mill oxide need not be removed if the surface is to withstand hot oxidation.

I find that the high melting point metals, tungsten, molybdenum, columbium, vanadium, zirconium, titanium, all have properties akin to tantalum in increasing the physical properties of my alloy in the soft or heat treated condition, or when subjected to high temperatures. Under the latter condition nickel and cobalt are effective. Nickel should be kept very high or low, that is over 15% or under 5%. With low nickel the scale resisting properties are adversely affected.

I find that it detracts from the easy working of the alloy to have more than 5% of the high melting point metals as additions, or for replacing in part the necessary tantalum content, and it is preferable to keep such additions under 3%, particularly if the chromium content is carried toward the upper end of my range.

For rustless iron or steel bars, my preferred composition is:

Carbon under .20%.
Chromium 10% to 17%.
Tantalum .20% up to 3%.
Silicon up to .50%.
Manganese up to .60%.
Phosphorus and sulfur low.
Balance iron.

High melting point elements I prefer to be not greater than 3% total, or the total tantalum and high melting point elements not greater than about 3%.

For piercing into tubes, I preferably make use of the above analysis, with the carbon below .10%, generally about .06%.

I claim:

1. A rust, heat and acid resisting ferrous alloy containing chromium about 7%–25%, an appreciable quantity of carbon under 1.25%, and an appreciable quantity of tantalum under 10%.

2. A rust, heat and acid resisting ferrous alloy containing chromium about 7%–25%, an appreciable quantity of carbon under 1.25%, and an appreciable quantity of tantalum under 5%.

3. A rust, heat and acid resisting ferrous alloy containing chromium about 7%–25%, an appreciable quantity of carbon under 1.25%, and about 2% of tantalum.

4. Rust, heat and acid resisting articles made from a ferrous alloy containing an appreciable quantity under 10% of tantalum, and containing carbon and chromium within the herein identified area *b*.

5. Rust, heat and acid resisting articles

made from a ferrous alloy containing an appreciable quantity under 10% of tantalum, and containing carbon and chromium within the herein identified area b'.

6. Rust, heat and acid resisting articles made from a ferrous alloy containing an appreciable quantity under 5% of tantalum, and containing carbon and chromium within the herein identified area b.

7. Rust, heat and acid resisting articles made from a ferrous alloy containing an appreciable quantity under 5% of tantalum, and containing carbon and chromium within the herein identified area b'.

8. Rust resisting ferrous alloy containing chromium 10%–17%, tantalum .2%–3.0%, silicon up to .5%, manganese up to .6%, an appreciable quantity of carbon under .2%, and the principal part of the remainder iron.

9. Rust resisting tubes made from ferrous alloy containing chromium 10%–17%, tantalum .2%–3%, silicon up to .5%, manganese up to .6%, an appreciable quantity of carbon under .1%, and the principal part of the remainder iron.

In testimony whereof, I have signed my name hereto.

PERCY A. E. ARMSTRONG.