

UNITED STATES PATENT OFFICE.

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PROCESS OF MAKING VANADIUM STEEL.

No Drawing.

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The invention is a process of making vanadium steels and comprises procedure whereby vanadium is incorporated directly into a steel bath without the preparation of a ferro-vanadium alloy as a preliminary step.

Vanadium is universally regarded as a powerful agent for the removal of oxygen and nitrogen from steel. Being in the generally accepted view an element of such great reactivity, it has apparently been regarded as impossible to reduce vanadium oxid by those constituents which are normally present in a steel bath. On the contrary, it has been assumed that vanadium is able to eliminate additional quantities of oxygen from steels already deoxidized with ordinary deoxidizing agents.

In accordance with my invention a vanadium oxid, such as the pentoxid V_2O_5 , is brought into contact with a steel bath of normal composition; and a steel is obtained which upon analysis shows the presence of vanadium, and which exhibits the refinement of grain, increase in elastic limit, and other improved properties which are characteristic of vanadium steels. No reducing agents not normally present in steel making are required to bring about the above result.

Whether or not the vanadium oxid is reduced in the process, and if reduced, to what degree, I am unable to say with certainty. I am inclined to doubt the generally accepted view that vanadium steels as usually produced contain the vanadium entirely in elemental form, and I also question the ability of vanadium to remove oxygen from steels of low oxygen content. My own observations upon the total oxygen content of "killed" steels with vanadium in customary small amount (0.10 to 0.25%), and without vanadium, indicate that such contents of vanadium tend to increase the total oxygen content appreciably.

The foregoing leads to the theory that vanadium, where present in steel in such small amounts as those referred to, exists not entirely in elemental form but in part as some suboxid, and that it is the presence of such suboxid, soluble in the liquid steel, which confers on the finished steel those improved properties which are usually associated with

a content of vanadium. This theory is supported by the observation that when ferro-vanadium is added to steel which contains a very powerful deoxidizer, such as zirconium, the characteristic effects of small percentages of vanadium do not appear. Instead, the vanadium acts in many respects like the chemically related element phosphorus and segregates badly as is shown by mechanical tests and microchemical examination. This behavior can be ascribed to the failure of the vanadium to combine with oxygen in the presence of zirconium. In the practice of my invention I therefore prefer that the concentration of reducing elements in the steel bath to which the vanadium oxid is added shall not be too high. A silicon content not higher than about 0.35% is preferred.

Regardless of the mechanism of the action which takes place, when vanadium oxid is added to a steel bath of normal composition I am able without difficulty to produce vanadium steels by the process described herein.

The following examples will illustrate the process:

I. To a heat of steel in a basic electric furnace there was added fused impure vanadium oxid analyzing 86.2% V_2O_5 . The amount added corresponded to an addition of 0.25% V to the steel. The addition was made during the refining or final slag period of the heat, immediately after an addition of high-carbon ferro-manganese. The silicon content of the bath was negligible. Twenty minutes after adding the vanadium oxid the metal was tapped and ferrosilicon was added in the ladle. The finished steel had the following composition:

	Per cent.	
C-----	0.63	90
Si-----	0.13	
Mn-----	0.56	
P-----	0.013	
S-----	0.007	95
V-----	0.17	

The recovery of vanadium was accordingly 68%.

In the case of the electric furnace heat cited above, the vanadium oxid was introduced into the furnace during the final or reducing period in accordance with the gen-

eral practice followed when using the ferroalloys, such as ferrovanadium and ferrochromium. The invention is not to be considered, however, as restricted to the addition of vanadium oxid to a steel bath covered with a so-called "carbide" or reducing slag, as I have found it possible successfully to incorporate vanadium in steel by adding an oxid of vanadium to molten steel in the absence of any slag, and under conditions which preclude a reduction by any agent other than the steel itself, as shown by the following examples:

II. Vanadium pentoxide in amount equivalent to 0.30% vanadium was added to a steel melt contained in a magnesia-lined crucible 35 minutes before pouring. No further additions were made to the melt until 5 minutes before pouring at which time ferrosilicon in normal amount was added. The finished steel analyzed 0.47% carbon, 0.31% silicon, 1.08% manganese, and 0.29% vanadium. Melting was conducted in a high frequency induction furnace in complete absence of reducing gases from any source extraneous to the melt itself, which at all times was free from any visible slag layer.

III. Another heat was made by the same procedure as in Example II except that the vanadium oxid employed was equivalent to only 0.20% V. The finished product analyzed as follows: 0.94% carbon, 0.30% silicon, 0.40% manganese, and 0.20% vanadium.

IV. Vanadium oxid equivalent to 1.0% V was added to Armco iron remelted in a crucible by the procedure described above and the melt was held for one hour after this addition was made. The contents of the crucible were poured into a small ingot mold without subsequent additions. The steel analyzed 0.04% carbon, 0.03% silicon, 0.02% manganese, and 0.36% vanadium.

So far as my experience extends, any form of vanadium oxid is applicable in the process. I prefer at the present time to use a product obtained by fusing at a dull red heat the chemically precipitated vanadium oxid produced in the usual vanadium concentrating process. A typical analysis of this product is as follows:

	Per cent.
V ₂ O ₅ -----	87.57
SiO ₂ -----	0.46
P ₂ O ₅ -----	0.21

	Per cent.	
CuO -----	0.60	55
As ₂ O ₃ -----	0.42	
PbO -----	0.26	
Fe ₂ O ₃ -----	5.96	
	95.48	60

I do not restrict myself to this or any other variety of the pentoxid, but may use other oxids of vanadium, such as the trioxid V₂O₃.

I regard the invention as especially applicable to the manufacture of vanadium steels containing not more than about 0.25% vanadium, and to the manufacture of such steels by the basic electric or crucible processes, but the invention is not restricted to such use. Obviously the scope of the invention is in no way to be dependent upon the correctness of the theory set forth herein concerning the manner in which vanadium exists in steels.

I claim:

1. The process of making vanadium steel which comprises bringing uncombined vanadium oxid into contact with a steel bath in the presence of only such reducing agents as are normally present in a steel bath, and maintaining the steel in a molten state under these conditions for a sufficient time to permit the desired quantity of vanadium to become incorporated in the steel.

2. The process of making vanadium steel which comprises bringing uncombined vanadium oxid into contact with a steel bath in the absence of reducing slag and extraneous reducing agents, and maintaining the steel in a molten state under these conditions for a sufficient time to permit the desired quantity of vanadium to become incorporated in the steel.

3. Process of making a vanadium steel containing less than about 0.25% vanadium which comprises adding previously fused vanadium pentoxid to a steel bath in a basic electric furnace, said bath containing only such reducing agents as are normally present during the finishing stage, and maintaining the steel in molten condition for a sufficient period thereafter to permit the desired quantity of vanadium to become incorporated into the steel.

In testimony whereof, I affix my signature.

ALEXANDER L. FEILD.