Patented Aug. 23, 1927. 1,639,989

UNITED STATES PATENT OFFICE.

CHARLES TYNDALE EVANS, OF TITUSVILLE, PENNSYLVANIA.

ALLOY STEEL AND METHOD OF MAKING IT.

No Drawing. Application filed April 18, 1922. Serial No. 555,280.

This invention relates to new ferrous metal alloys and methods of making them.

The object of the invention is to provide a metal which has the characteristics of steel, but which is non-corrosive in its ingot form and in subsequent stages.

It has been possible heretofore to provide certain alloys of a steel-like nature which, when hardened, are non-corrosive or stainless. These alloys contain high percentages of chromium, for example, from 9% to 16% (thus differing from the so-called "high-speed" steels which contain lower percentages of chromium) and are not non-corrosive or stainless in the ingot form and prior to the hardening, although somewhat more resistant to corrosion than are the common steels. Furthermore, the high chromium content of such alloys tends to render them brittle, so that the cost of working the material is high and is attended by considerable loss, thus rendering such articles made from steels unduly expensive. In fact some of the stainless steels on the market prior to my invention do not develop their stainless properties until polished. Furthermore, on account of the high chromium content of these prior so-called stainless steels they are difficult to forge and when made into cutlery or the like do not maintain a good cutting edge.

Because of the necessity of hardening such prior so-called stainless steels in order to develop the stainless properties, they have not been satisfactory for some purposes where a non-corrosive steel would otherwise be valuable. For example, a strong and non-corrosive steel pump rod would be a valuable article, but those prior so-called stainless steels which have sufficient strength were objectionable for such use because if hardened they could not be fitted with keyways or otherwise worked to the proper dimensions. If worked to shape and used without hardening, they were not truly non-corrosive and were no better than ordinary steels, while, if first worked to shape and then hardened, they were likely to, and generally did, change their dimensions and shape,—that is, warped,—so that they could not be fitted into place.

By the present invention, however, an alloy is provided having the desirable properties of a good steel, and which is as readily worked by forging and machining as are the usual steels employed for machinery and cutlery purposes, this alloy having the further advantage over the usual steel that it is non-corrosive in all stages prior and subsequent to heat treatment.

Although this material cannot really be hardened by heat treatment, it is hardened by mechanical work. For example, after forging or rolling it is very much harder than prior thereto.

By "non-corrosive", I mean, the alloy is practically unaffected by organic acids, weak inorganic acids, or alkalies, and is practically not corroded by the action of the atmosphere or salt-water.

I will now give the formula for a ferrous alloy embodying the desired product in one of its preferred forms:

	Per cent.
Carbon	0.40
Chromium	7.50
Nickel	19.50
Manganese	.75
Silicon	1.25

The principal remaining ingredient is iron.

The above may be termed an ideal analysis, which may not always be obtained in practice. In regular manufacturing operations the alloy steel usually contains some phosphorous, and some sulphur. These are impurities which should be avoided as much as possible. Also some copper may be found in the alloy, this usually being brought in with the iron. A small amount of copper, for example, about 0.35 percent, is not objectionable, particularly if the manganese content is kept as high as 1 per cent or is increased somewhat above this amount.

In actual practice, steel alloys have been produced which have all the properties desired and which have analyses falling within the following limits:

	Per cent.
Carbon	0.40 to 1.00
Chromium	3.50 to 7.75
Nickel	10.00 to 20.00
Manganese	0.25 to 2.50
Silicon	0.15 to 2.50
Copper	0.05 to 0.35
Phosphorus	About 0.015
Sulphur	About 0.015

The principal remaining ingredient was iron.

Generally speaking, steel alloys of the character contemplated by the invention

should contain not substantially less than 0.40 per cent of manganese and not substantially less than 0.50 per cent of silicon.

An important feature of my invention consists of the process for making the new product hereinbefore described. This process consists in preparing a starting mixture of such ingredients and in such proportions as will, when melted, give the new alloy steel hereinbefore described, and adding to this mixture prior to or at the time of melting it a small amount of zirconium, usually in the form of ferro-zirconium or silico-zirconium.

By this process the desired product is obtained with greater certainty and with less care in operation.

By the use of a restricted amount of the zirconium in the mix, no zirconium will be found on analysis of the resulting alloy steel, or at most only such a small amount that it cannot be detected by the ordinary methods of analysis employed in steel works.

As one example of a mix which may be employed in my new process I submit the following:

	Parts.
Iron	650
Nickel shot	205
Ferro-chromium	108
Manganese metal	8
Ferro-silicon	14
Silico-zirconium	15

The mix was melted in a crucible in the usual way, was cast into an ingot and then worked down, all as in the usual steel making processes. One product obtained from the above mix gave the following analysis:

	Per cent.
Carbon	0.374
Nickel	19.38
Chromium	7.52
Silicon	1.22
Manganese	0.685

The principal remaining ingredient was iron.

In making the mix it is advantageous to use an iron which has a low carbon content and which is freed from impurities as much as possible, particularly from sulphur and phosphorus. In other words, pig iron, for example, would not be suitable, whereas a refined iron, and particularly one of the type corresponding to the so-called Norway or Swedish iron would be satisfactory.

While the mix set forth above is particularly suitable for the purposes intended, it is to be understood that certain variations are permissible without departing from the invention. For example, instead of zirconium or its compounds, I may use cerium or titanium with good results, these being added to the mix in about the proportions stated for the zirconium.

What is claimed is:

1. An alloy steel comprising the following ingredients in substantially the following percentages: chromium 3.50 to 7.75; nickel 10 to 20; carbon 0.40 to 1.00; manganese 0.40 to 2.50; silicon 0.50 to 2.50; the remainder being principally iron.

2. An alloy steel comprising the following ingredients in substantially the following percentages: chromium 3.50 to 7.75; nickel 10 to 20; carbon 0.40 to 1.00; manganese 0.40 to 2.50; silicon 0.50 to 2.50; copper 0.05 to 0.35; the remainder being principally iron.

3. An alloy steel comprising chromium, nickel, carbon, manganese, silicon and iron, the percentage of nickel being not substantially less than 10%; that of chromium from 3.50 to 7.75; of carbon from 0.40 to 1.00; of manganese 0.40 to 2.50; of silicon 0.50 to 2.50; the remainder being principally iron.

4. An alloy steel comprising chromium, nickel, carbon, manganese, silicon and iron, the percentage of carbon being not greater than 1%; that of nickel being not substantially less than 10%; that of chromium from 3.50 to 7.75; that of manganese from 0.40 to 2.50; that of silicon from 0.15 to 2.50; the remainder being principally iron.

In testimony whereof, I have hereunto set my hand.

CHARLES TYNDALE EVANS.