UNITED STATES PATENT OFFICE.

WILLIAM LAWRENCE TURNER, OF ATHERSTONE, ENGLAND.

MANUFACTURE OF STEEL.

1,360,830. Specification of Letters Patent. Patented Nov. 30, 1920.

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To all whom it may concern:

Be it known that I, WILLIAM LAWRENCE TURNER, a subject of the King of England, and residing at Atherstone, in the county of Warwick, England, have invented Improvements in the Manufacture of Steel, of which the following is a specification.

This invention has reference to the manufacture of steel or ferro-alloys, especially that grade of steel known as "high speed tool steel" in the constitution of which metals such as chromium, vanadium, tungsten, titanium, or the like, enter.

Steel of the character referred to (which is in fact a ferro-alloy involving several constituents), as made by the proccesses hitherto employed, is expensive, the expense being entailed to a large extent by the nature or character of the process or mode of manufacture hitherto adopted, which involves first, the manufacture of certain ferro-alloys of metals as above specified, or the said metals, (which are commercially free from carbon), which is a complete process in itself, and the subsequent use and application of such alloys or metals in a secondary melting process in conjunction with iron, or steel.

As regards these processes hitherto employed, it is well-known in the manufacture of steel of the character herein concerned, that pulverized metallic tungsten or ferro-tungsten has been introduced into a furnace containing molten cast iron or steel, and that in carrying out this process disadvantages occur as carbon or oxidation impurities were introduced together with the metallic tungsten or the ferro-tungsten which had been produced in an electric furnace, and it was very difficult to alloy these substances with the body of molten cast iron or steel, and also a wastage of tungsten took place; and it has been proposed to avoid these disadvantages by adding to the bath of cast iron or steel a mixture of ferric-oxid, aluminium, tungstic-acid, and lime, or tungstate of calcium. By this, the alumino-thermic reaction, which immediately takes place, produces a pure ferro-tungsten of high percentage, which alloys freely and without waste with the cast iron or steel, the easily fusible slag remaining liquid on the surface of the bath; but this process is obviously not a single-act process as described and claimed hereunder.

Further, it has been proposed in the manufacture of iron or steel, to use prepared iron ore as the source of iron and aluminium in carrying out the reduction of iron by the well-known alumino-thermic process, either for the direct production of iron for joining metal articles or parts together by performing the operation of reduction around or on the metal parts to be joined, or for the manufacture of iron or steel direct from the iron for other purposes; and in such processes it has been proposed to introduce material such as ferro-maganese, spiegeleisen or iron containing the requisite quantity of carbon, either prior to or during the reaction, and no general claim is made to such process hereunder.

Now according to this invention, the production of steel or ferro-alloys of the character described, at a substantially less cost than that hitherto entailed, is effected by a single act and process hereinafter described, consisting of the direct chemical reaction of aluminium, magnesium, silicon, or the like reducing elements with the ores, oxids, or salts of chromium, vanadium, tungsten, titanium, or the like, in conjunction with iron—forming the predominant ingredient of such steel, and carbon.

It is well known that when aluminium, magnesium, silicon, etc., is intimately mixed in chemically equivalent proportions with metallic oxids, sulfids, chlorids, and salts of metals, of the kind referred to, such mixture may be by the application of heat, set into reaction, with the result that the metallic substances are brought to a molten state, and reduced, with the production of metal alloys, as ferro-alloys, or metals, which are capable of use, and are used for various purposes in the metal industries.

As a general designation, this process is called the alumino-thermic process, and has been profitably utilized for the commercial production of ferro-alloys of the metals, or the metals such as referred to, viz., chromium, vanadium, tungsten, titanium, manganese, etc.

The use of such alloys or metals made by the alumino-thermic process, in the manufacture of steel, has advantages which are known to those who are concerned with its manufacture or production, and which do not obtain when such metals or ferro-alloys are produced by other wellknown methods.

In the manufacture of this steel, having regard to its required ultimate composition varying proportions of the different metals or metallic substances named are employed,

and according to this invention a mixture of the whole of these substances in the form or manner hereinafter described, and aluminium, silicon, magnesium, or the like, is taken, and all are melted and reduced by the reaction due to the latter metals, at the one time, and by the one operation, with the result of the direct production of a body of steel or ferro-alloy of the special species referred to.

The chemically equivalent mixtures of metal oxids, sulfids, chlorids, or other salts, and the aluminium or other reducing metal, may conveniently be designated generally by the name "thermit" (which name is generally today applied to the admixture of iron oxid and aluminium), and the word "thermit" hereinafter associated with certain metallic substances named, would mean a chemically equivalent mixture of the metallic substances, and the aluminium or other reducing metal used.

In carrying out the manufacture of steel according to this process, in which chromium, nickel, cobalt, vanadium, tungsten, molybdenum or the like are to be employed, there will be used iron thermit, nickel thermit, cobalt thermit, vanadium thermit, tungsten thermit, molybdenum thermit, etc., all of which consist of an intimate mixture of the oxids, ores, sulfids, chlorids, or salts of such metals as the case may be, and aluminium or like metal, and containing such metal in the proper equivalent proportion necessary for the production of the several metals or ferro-alloys of these metals, which are customarily produced today by a separate process, and are subsequently used in the industry of the manufacture of steel, and especially high speed tool steel, by a separate process.

In the carrying out of this invention, in the manufacture of tool steel, and especially high speed tool steel directly from oxids, sulfids, chlorids, and salts of metals of the kind referred to, a mixture of the several thermits above specified or some of them, and in certain proportions for the production of the steel or alloy required, is taken, and in conjunction with the iron, and a certain proportion of carbon, as hereinafter described, is set into reaction, and the heat generated thereby, results in the production of the tool steel referred to. Or, some of these metal thermit mixtures may be taken and used, and mixed with the metallic substances required, such as vanadium and chromium, which may be used in the form of ferro vanadium, or ferro chromium.

In the production of steel of the kind referred to by separate processes, and by the use of already manufactured ferro-alloys of the metallic substances mentioned, these are taken by the steel maker, and melted in a furnace with the iron or steel which is to form the basis of the tool or alloy steel; and one of the chief objects or advantages of using these ready made ferro-alloys produced by the "alumino-thermic" process, is that these alloys are chemically free of carbon, so that the regulation of the amount of carbon content in the composition or mixture for the production of the tool steel, can be more easily and accurately regulated and controlled; but in the process according to this invention, the carbon is added or provided in the total reaction mixture, and the proportion may be furnished in the manner hereinafter referred to.

I have found by my tests that by mixing the substances referred to, and adding or providing a quantity of carbon as herein provided, I have been enabled to obtain by this process a tool steel having a practically identical composition to similar steel manufactured by other and more expensive indirect or multiple act processes in practice today.

It is found that in carrying out the above mentioned process, in which the various required thermit substances are mixed together and set into reaction, the heat generated thereby is more than sufficient to completely melt or fuse the resulting metal and slag; and in carrying out the process, in some cases, this heat is economically reduced to a degree in which the steel remains sufficiently liquid, but can be more conveniently dealt with, by adding to the various thermits, certain quantities of say metallic iron; and as this material can be more economically added than it can be produced by the "alumino-thermic" process, it will be seen that the cost of the resultant metal is accordingly reduced.

With regard to the introduction and provision of the required proportion of carbon into the steel to be made, this is done by the addition to the mixture of suitable forms or species of steel or iron containing a certain amount of carbon necessary to give the required product. Or, this carbon can be provided in a modified manner by using in the mixture, instead of for instance the chromium thermit, or some of it, a correct and required quantity of ferro-chromium alloy containing the desired limits of carbon; and such alloys may be procured containing any limits of carbon up to 10%.

Similarly, other ferro-alloys containing carbon may in part or in whole be used instead of the thermit mixtures of these metallic substances, according to requirements and different conditions of manufacture.

Further, in some cases there may be introduced into the mixture where desirable, small quantities of high speed or like steel scrap, containing in addition to carbon such metals as tungsten, vanadium, chromium,

etc., which would accordingly be recovered in the operation of this process.

As an illustration of the manufacture of high speed tool steel according to this invention, a combination of constituents, and the manner of their application and use, is as follows:—

2570 lbs. of iron thermit.
560 lbs. of wolfram thermit.
70 lbs. of cobalt thermit.
55 lbs. of wrought iron or mild steel in a small state of division.
40 lbs. of ferro vanadium, containing 35% of vanadium. (Carbon free.)
140 lbs. of ferro chromium containing 60% chromium and about 8% carbon.

Each of the said metal thermits will be prepared previously in the ordinary way as described, from the ores, oxids, etc., of the metals specified.

This mixture would be set into reaction say in a crucible or furnace in the manner in which the alumino-thermic reaction is carried out, or in any other suitable way; and the resulting fluid steel would be tapped or poured out and cast into the form desired, such as an ingot, and ultimately dealt with in any way according to the use to which the said steel is to be put or required.

An actual steel produced from the constituents just specified, and produced in the manner herein set forth under this invention, has given the following chemical analysis:—

Carbon	.743%
Cobalt	2.6 %
Chromium	4.07 %
Vanadium	.615%
Tungsten	16.16 %
Manganese	.55 %
Iron	73.64 %

Similarly, other tool or alloy-steels may be produced, the specific constituents and quantities of which will depend upon or be governed by the character or quality of the steel required.

What is claimed is:—

1. A process for producing high speed steel, which consists in mixing a reducing metal, iron, and an alloy metal of a character capable of combining with the iron to form high speed steel, heating the mass to cause a chemical reaction to be set up between the reducing metal and alloy metal compound whereby the metallic alloy metal is produced, and utilizing the heat from the reaction to melt the iron in the presence of the alloy metal so that it combines with the molten iron.

2. A process for producing high speed steel, which consists in mixing a reducing metal, iron, and an alloy metal of a character capable of combining with the iron to form high speed steel, with the iron present in excess, heating the mass to cause a chemical reaction to be set up between the reducing metal and alloy metal compound whereby the metallic alloy metal is produced, and utilizing the heat from the reaction to melt the entire mass including the iron, which in the presence of the alloy metal combines with the same.

3. A process for producing high speed steel, which consists in mixing a reducing metal, carbon, iron, and an alloy metal compound of a character capable of combining with the iron to form high speed steel, the iron being present in a preponderance with respect to the other constituents, heating the mass to cause a chemical reaction to be set up between the reducing metal and alloy metal compound, and utilizing the heat from the reaction to melt the iron in the presence of the alloy metal formed.

4. A process for producing high speed steel, which consists in heating alloy metal thermits of a character capable of combining with iron to form high speed steel and containing suitable quantities of metallic iron in the presence of a preponderance of iron for setting up a chemical reaction between the constituents of the thermits, and utilizing the heat from this chemical reaction for melting the preponderance of iron, the iron present in the thermits controlling the degree of heat caused by said reaction.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM LAWRENCE TURNER.

Witnesses:
A. M. HANNAN,
SOMERVILLE GOODALL.