

UNITED STATES PATENT OFFICE.

ROBERT A. HADFIELD, OF SHEFFIELD, COUNTY OF YORK, ENGLAND.

PROCESS OF MAKING STEEL CONTAINING CARBON, MANGANESE, AND ALUMINIUM.

SPECIFICATION forming part of Letters Patent No. 422,403, dated March 4, 1890.

Application filed August 29, 1887. Serial No. 248,213. (No specimens.)

To all whom it may concern:

Be it known that I, ROBERT A. HADFIELD of Sheffield, in the county of York, Kingdom of Great Britain, have invented a new and useful Process of Making Steel Containing Carbon, Manganese, and Aluminium; and I do hereby declare the following to be a full, clear, and exact description thereof.

This invention relates to the manufacture of a new and useful metallic alloy or admixture, the principal constituents of which are iron, (Fe,) carbon, (C,) silicon, (Si,) manganese, (Mn,) and aluminium, (Al,) but which may also contain other ingredients—such as sulphur and phosphorus—as they are necessarily present in the metal.

The injurious effect of the presence of sulphur and phosphorus in the cheaper qualities of iron has largely prevented their use in the manufacture of high grades of steel, and has consequently made the cost of production of such high grades of steel much greater than if ordinary low grades of steel-making irons can be employed. I have discovered, however, that by adding carbon, silicon, manganese, and aluminium to iron, (Fe,) in certain proportions hereinafter specified, that cheap and common qualities of irons can be used, and results can be obtained therefrom equal to those from the steel made with the most expensive brands of Swedish and other foreign irons, thereby dispensing with such latter and effecting enormous economy in the manufacture of steel of superior quality. I am aware that the use of aluminium has been before suggested, so long ago as in the time of Faraday, but only in laboratory experiments of no practical use or value, and in no way indicating commercial and practicable methods of manufacture. Besides, also, in some of the so-called steels said to contain aluminium, after many most careful analyses, I have been unable to detect even the slightest trace of aluminium. In fact, hitherto no commercial application has been possible, from the fact that aluminium alloys have not been produced on any practical scale. It is only lately that such alloys of ferro-aluminium (*i. e.*, aluminium and what may be termed "cast-iron," alloyed together in the same way as silicon and cast-iron are alloyed together, and termed "ferro-silicon,") have been obtain-

able. Consequently it was formerly impracticable to produce aluminium steel. While laboratory experiments may have been made with this metal, they have been only with very minute quantities under the limits now claimed and specified. I claim to be the first person who makes patent proper methods and processes necessary to be employed in producing aluminium steel. My product also differs from any such previous employment of aluminium, as I claim a simultaneous employment of carbon, silicon, and manganese, together with aluminium. My invention also produces a steel possessing a very superior quality from cheap brands of irons hitherto considered unfit for making high-class steels, but now applicable and suitable by means of my improvements here detailed.

The condition of the iron which forms the basis of my improved steel and from which it is manufactured may be that of ordinary steel-making pig metal, cast-iron, wrought-iron, steel or iron scrap, or a mixture of any or all of these, and the process or processes by which the iron or steel is manufactured or produced or subsequently treated is immaterial, the only necessary requirement being that the iron before the introduction of the carbon, silicon, manganese, and aluminium additions should be substantially decarburized; hence my improved process is applicable to the manufacture of iron and steel by means of the Bessemer, open-hearth, or crucible processes, these processes being carried on in the usual way as to the first two named until the metal under treatment is substantially decarburized, and then the desired percentages of carbon, silicon, manganese, and aluminium are added, while if the crucible process is employed such additions may be introduced at any stage of the process. In the introduction of such additions, however, it must be observed that it is essential that if the Bessemer or open-hearth processes are employed the said additions must be introduced after the iron has been decarbonized or substantially decarburized, for the reason that in the oxidizing process necessary for decarburizing the charge the carbon, silicon, manganese, and aluminium would be oxidized and eliminated, so that if the said additions were introduced previously to or during the decar-

burizing operation they would not remain in the charge or be found present in the resulting product.

In practicing my invention the charge may be composed of pig metal, cast-iron, scrap, or a mixture of these with steel or wrought-iron scrap, which are melted, desiliconized, and decarburized in the ordinary way. When the charge is refined in the open-hearth process, and the blow is finished in the Bessemer process, the carbon, silicon, manganese, and aluminium additions are introduced into the charge. The amounts of such additions are necessarily regulated according to the desired percentages of carbon, silicon, manganese, and aluminium required to be present in the resulting product. If the crucible process is used, the basis of the operation or prime charge being wrought iron or steel scrap, or both combined, the process is conducted in the usual way, and the additions introduced in the crucible with the prime charge or afterward at any stage of the process. The percentages of carbon, silicon, manganese, and aluminium are introduced as follows by means of alloys or admixtures herein termed "additions." The carbon addition may consist of hematite pig metal, cast-iron, or other carbonaceous iron. The silicon addition may consist of silicon, pig-iron, or other ferro-silicon. The manganese addition may consist of spiegel, high or low ferro-manganese, or other manganese addition. The aluminium addition may consist of aluminium pig-iron, (a well-known product,) ferro-aluminium, or other aluminium addition; or, if requisite, each of these additions may be added in their metallic state, or as nearly in their metallic state as it is possible to obtain such alloys. For instance, manganese alloys have been produced which contained over ninety per cent. of metallic manganese. Such a material can hardly be termed "ferro-manganese;" also, as mentioned in metallurgical literature, alloys of cast-iron and aluminium have been produced containing eighty-five per cent. of aluminium. It is also obvious that such additions may be made by means of a compound alloy containing all the above metals; or the carbon, silicon, and manganese may be added in one alloy and the aluminium by means of a separate alloy, and so on. In fact, these additions may be varied according to choice and convenience, though I prefer to add each constituent by means of separate alloy, having thereby special and greater control over the result. The additions may be introduced either broken up and preferably heated, or, better still, in a melted state. After the additions are incorporated with the charge it is ready to be run into ingots or other forms, as may be desired.

As an example of manufacture, I add to, say, 2,000 (two thousand) pounds of decarbonized iron, 200 (two hundred) pounds of ferro-silicon, containing 15 (fifteen) per cent. of

silicon, 50 (fifty) pounds of ferro-manganese, containing 80 (eighty) per cent. of manganese, 500 (five hundred) pounds of ferro-aluminium, containing 9 (nine) per cent. of aluminium. Such steel would be approximately composed of 1 (one) per cent. of carbon, 1 (one) per cent. of silicon, 1½ (one and a half) per cent. of manganese, and 1½ (one and a half) per cent. of aluminium. The product would be dense, close grained, and capable of being forged and rolled.

I may add that as the ferro-silicon, ferro-manganese, and ferro-aluminium alloys contain carbon, when they are used it will generally be found unnecessary to add any separate carbon addition.

The range of proportions which I desire to secure as my invention in this patent is as follows: Carbon from .10 (one-tenth) of 1 (one) per cent. to 3 (three) per cent., silicon from .10 (one-tenth) of 1 (one) per cent. to 6 (six) per cent., manganese from .10 (one-tenth) of 1 (one) per cent. to 30 (thirty) per cent., aluminium from .10 (one-tenth) of 1 (one) per cent. to 20 (twenty) per cent.

My improved steel is suitable for either castings or for steel that has to be forged and its constituents vary according to the purpose for which the steel is required. Owing to the wide range of articles for which this steel is applicable, it is difficult to give in any short statement an account of the different qualities into which it can be made. To any one versed in the art, and as indicated in my previous patents for manganese and silicon steels, it will be seen that such variations can be readily made as may be required. For milder qualities I add smaller amounts of the alloys, increasing same according to the hardness desired.

By the term "metal" in the following claims I mean iron or steel in any or all of the forms or conditions mentioned in the second paragraph of this specification.

By the term "charge" in the following claims I mean the charge as described in the third paragraph of this specification.

Having thus described my improved steel and the manner in which the same may be manufactured, what I claim as my invention, and desire to secure by Letters Patent, is—

1. The method herein described of manufacturing steel or metallic alloy by the introduction into the charge of metal under treatment, which has been refined and decarbonized to the desired degree by the same or by a previous independent operation, of a charge of carbon, silicon, manganese, and aluminium additions in such proportions to the main charge as to produce a resulting metal containing from one-tenth of one per cent. to three per cent. of carbon, one-tenth of one per cent. to six per cent. of silicon, one-tenth of one per cent. to thirty per cent. of manganese, and one-tenth of one per cent. to twenty per cent. of aluminium, substantially as herebefore described.

2. As a new article of manufacture, steel containing, in combination, carbon, manganese, and aluminium, each in the proportion of more than one-tenth of one per cent., substantially as and for the purposes described.

5 3. As a new article of manufacture, steel containing, in combination, carbon, silicon, manganese, and aluminium, the said ingredients being in proportions of carbon from
to .10 (one-tenth) of 1 (one) per cent. to 3 (three) per cent., silicon from .10 (one-tenth) of 1 (one) per cent. to 6 (six) per cent., manganese from

.10 (one-tenth) of 1 (one) per cent. to 30 (thirty) per cent., aluminium from .10 (one-tenth) of 1 (one) per cent. to 20 (twenty) per cent.

In testimony whereof I have hereunto set my hand this eighth day of August, A. D. 1887.

R. A. HADFIELD.

Witnesses:

JOHN A. KIPLING,
ARTHUR BROOK.