UNITED STATES PATENT OFFICE.

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

PROCESS OF MAKING STEEL.

SPECIFICATION forming part of Letters Patent No. 342,869, dated June 1, 1886.

Application filed May 7, 1885. Renewed December 8, 1885. Serial No. 185,091. (No specimens.) Patented in England December 4, 1884, No. 15,949.

To all whom it may concern:

Be it known that I, ROBERT HADFIELD, a subject of the Queen of Great Britain, residing at Sheffield, in the county of York, England, have invented certain new and useful Improvements in Processes of Making Steel, (for which I have received Letters Patent in England, No. 15,949, dated December 4, 1884;) and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to the manufacture of a new and useful metallic alloy or admixture, the principal constituents of which are iron and silicon, but which may also contain carbon, as well as other ingredients—such as sulphur and phosphorus, necessarily present in the metal—such alloy having most of the qualities peculiar to ordinary carbon steel, besides other qualities peculiar to my improved metal, which qualities are described in my pending application No. 172,984, for Letters Patent for improvement in steel. This improved metal I shall speak of as "steel," although the presence of carbon, while not injurious, is unessential, the metal depending for its steely qualities chiefly on the presence of a large percentage of silicon.

The condition of the iron which forms the basis of my improved steel, and from which it is manufactured, may be that of ordinary pig metal, cast-iron, steel, 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 reduced, or subsequently treated, is immaterial, the only necessary requirement being that the iron, before the addition of the silicon, should be substantially decarburized, by which I mean not necessarily devoid of carbon, but that the metal should be or should have been previously decarburized wholly or to a great extent. Hence my improved process is applicable to the manufacture of iron or 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 nearly or quite decarburized, depending upon whether any, and if any, what amount of carbon is to be present in my improved steel, and then the desired percentage of silicon is added, while, if the crucible process is employed, the silicon addition may be introduced at any stage of the process.

Hitherto in the manufacture of high-class steels it has been considered necessary to employ the best and most costly qualities of iron, and to reduce the percentage of silicon in the resulting steel to the lowest point practicable—say, one-tenth of one per cent. or less—so as practically to exclude silicon therefrom, as its presence in the steel has been supposed to be injurious. I have discovered, however, that if silicon is present in sufficient quantity—say, one and one-half per cent. to five per cent.—the resulting product is a steel of very superior quality and possessing certain marked characteristics, and I have also discovered that when this is the case the presence of phosphorus and sulphur in the iron which forms the basis of the process to a degree which would materially injure ordinary steel is no disadvantage whatever. There is, however, a practical difficulty in the production of an alloy or mixture of silicon and iron having the desired percentage of silicon arising from the fact that in the process of refining and decarburizing the metal the silicon present is oxidized before the carbon, so that, especially in the open hearth, puddling, and Bessemer processes, it has been ascertained by analyses made of the metal at different stages of treatment that the amount of carbon remains undiminished until the silicon has been removed below the point necessary to produce my improved steel, so that although a large percentage of silicon be present in the charge of iron under treatment, or be added thereto previous to the process of reduction, refinement, or decarburization, the resulting metal, even after only a partial decarburization, is almost entirely desiliconized.

In the practice of my invention, if pig metal, cast-iron, scrap, or a mixture of these with steel or wrought-iron scrap, is used as the basis, the metal is treated in the ordinary way by the Bessemer, open-hearth, or other decarburizing and refining process or apparatus until the melted charge is decarburized to the desired point, more or less carbon being left in the metal, as may be desired. By this time any

silicon which was present in the charge before treatment will have been practically eliminated by oxidation, so that if the oxidizing process is arrested when the silicon is added the exact amount or percentage of silicon added to the charge at that point of the process will be easily determined, the amount of silicon present in the silicon addition being previously ascertained, and will be present in the resulting steel at the close of the operation. The silicon is introduced into the wholly or sufficiently decarburized metal substantially in the same manner as spiegeleisen is commonly added as a final step in the process of making steel by the Bessemer steel-making process. This is done by the use of silicon pig-iron, hereinafter referred to as silicon addition, (a well-known product of the blast-furnace process,) or other ferro-silicon, which is incorporated with the charge, as above stated, either in a solid or melted condition. The gross amount of silicon pig or ferro-silicon to be added will depend on the amount of silicon which it contains, which will be ascertained before hand, and also, of course, on the percentage of silicon which the resulting steel is desired to contain. I prefer to use as the silicon addition silicon cast-iron or silicon pig-iron containing from eight to ten per cent. of silicon, for the reason that such material is low in carbon, and being a special product is more uniform in its quality and constituents.

As an example of manufacture, I add to two thousand pounds of decarburized and desiliconized iron six hundred and fifty pounds of the silicon pig-iron herein referred to, also, if necessary, a sufficient quantity of ferro-manganese; but usually the silicon pig contains sufficient manganese without requiring a separate addition thereof. It is desirable to keep the carbon under one per cent. in those steels containing two and one-half per cent. of silicon and upward, on account of the difficulty which would be experienced in working the ingots when such percentage of carbon is exceeded.

Where it is desired that the resulting product should have great toughness, I introduce such amount of the siliconizing addition as will yield a steel having from one and a half to two per cent. of silicon, and where greater hardness is required I increase the amount of silicon in varying proportions up to about five per cent. After the silicon addition is incorporated with the charge it is ready to be run into ingots or other forms, as may be desired.

If my improved steel is to be made by the crucible process, the basis of the operation or prime charge being wrought-iron or steel scrap, or both combined, the process is then conducted in the usual way, the amount of carbon, if any is used, being preferably less than in the ordinary steel-making operation, and the siliconizing addition is introduced into the crucible at any stages of the process and becomes thoroughly incorporated with the charge.

Manganese may be added to the steel made by my process in the usual way.

My improved steel thus manufactured possesses after tempering peculiar hardness, (depending in degree, as before stated, on the amount of silicon which it contains,) so that it is specially adapted for what is known as "tool-steel" purposes, edge-tools, &c. It has also other peculiar and valuable characteristics, among which I would mention that it has great toughness as compared with the tool-steel now used. It is more waxy and malleable in working when heated than high-carbon steel, and is therefore more readily shaped under the hammer, and when cold is more easily cut and tooled than ordinary steel. It is not so brittle as ordinary steel, and is less liable to be burned in heating and to what is known as "water-cracking." It is also susceptible of hardening and tempering by the same methods and with substantially the same effect as carbon steel.

Having thus described my improved process of making steel, what I claim as my invention, and desire to secure by Letters Patent, is—

The method herein described of manufacturing silicon steel by the introduction into the charge of metal under treatment, which has been previously refined, desiliconized, and decarburized to the desired degree by the same or by a previous independent operation, of a charge of a silicon addition in such proportion to the main charge so as to produce a resulting metal containing from one and a half to five per cent. of silicon, substantially as hereinbefore described.

ROBERT HADFIELD.

Witnesses:
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