

UNITED STATES PATENT OFFICE.

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STEEL OR METALLIC ALLOY.

SPECIFICATION forming part of Letters Patent No. 461,333, dated October 13, 1891.

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To all whom it may concern:

Be it known that I, ROBERT A. HADFIELD, of Sheffield, in the county of York, England, a citizen of Great Britain, have invented a new and useful Improvement in Steel or Metallic Alloys; and I do hereby declare that the following is a full, clear, and exact description thereof.

My invention relates to the manufacture of a new alloy or steel, the principal constituents of which are iron, carbon, silicon, chromium, and aluminium, and which may also contain other ingredients, such as sulphur and phosphorus, necessarily present in the metal. The injurious properties of sulphur and phosphorus in cheaper qualities of iron have largely prevented their use in the manufacture of high grades of steel; but I have discovered that by the addition of silicon, chromium, and aluminium in certain proportions such cheap qualities of iron can be used and steel of very fine quality obtained therefrom.

The iron, which forms the principal constituent of my improved steel or alloy, may be used in the form 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 by which the steel or iron is subsequently treated is not essential. In using the Bessemer or open-hearth processes in the manufacture of my alloy I carry on the process in the usual way until the iron has been substantially decarbonized and desiliconized, and then add to it the other constituents of the alloy. In this way I prevent the loss of such constituents by oxidation. When the crucible process of steel-making is employed in the manufacture of the alloy, the chromium, silicon, and aluminium may be introduced at any stage of the operation, either with the prime charge before the melting or afterward, when the iron or other scrap has been melted.

The percentages of silicon, chromium, and aluminium are introduced by means of alloys or admixtures containing these elements. The silicon addition may consist of silicon pig-iron or other ferro-silicon; the aluminium addition may consist of aluminium pig-iron, or a well-known product, ferro-aluminium, or

other aluminium addition; and the chromium addition may in like manner consist of chrome pig-iron or other ferro-chrome; or, if desired, these constituents may be added in their metallic state or as nearly in their metallic state as it is possible to obtain them. These additions may be made also by a compound alloy containing all of these elements, or the silicon and chromium may be added in one alloy and the aluminium by a separate alloy, &c.; but I prefer to add each constituent by a separate alloy, since I have therefore greater control over the result. The additions should also include carbon, which may be present in one or more of the alloys or may be added by means of cast-iron, hematite pig metal, or other carbonaceous iron. The additions may be introduced either broken up or preferably heated, or, better still, in a melted state, and after their incorporation with the iron it is ready to be run into ingots or other desired forms.

As an example of manufacture, I add to, say, one thousand pounds of decarbonized iron twenty-five pounds of ferro-silicon containing ten per cent. of silicon, forty pounds of ferro-chromium containing twenty-five per cent. of chromium, and ten pounds of ferro-aluminium containing ten per cent. of aluminium, carbon being present to the amount of about one-quarter of one per cent. of the total addition, including the iron. The result would be a steel or iron alloy containing about one-quarter of one per cent. of carbon, one-quarter of one per cent. of silicon, one per cent. of chromium, and one-tenth of one per cent. of aluminium. I may also add, as another constituent, manganese in the form of spiegeleisen or ferro-manganese—say, ten pounds of ferro-manganese containing eighty per cent. of manganese—which would give to the product a percentage of eight-tenths of one per cent. of manganese. The proportions of the constituents desired in the final product being known and the proportions in which they are present in the additions being ascertained by well-known chemical tests, the skilled steel-maker by a simple calculation will know in what relative amounts the additions should be made.

The range of proportions of the constituents which my improved steel or alloy should contain in order to gain the benefits of my invention are as follows: carbon, from five
 5 one-hundredths of one per cent. upward; silicon, from five one-hundredths of one per cent. upward; chromium, from five one-hundredths of one per cent. upward; aluminium, from five
 10 one-hundredths of one per cent. upward; manganese, (when desired,) from five one-hundredths of one per cent. upward.

My improved steel is tough and possesses great tensile strength. It is suitable for castings or for steel that is to be forged, and its
 15 constituents should be varied according to the purpose for which the steel is intended to be used. The steel produced by the sample operation described above is dense, close-grained, tough, and easily capable of being
 20 forged and rolled. As the proportions of the additions are increased the steel becomes gradually harder and less malleable, and by bearing this in mind the operator may, within the limits of my invention, obtain products
 25 suitable for a great variety of uses—*e. g.*, for car-wheel tires, steel shot and shell, castings of various kinds, &c.

The effect of adding manganese in small proportions (from five one-hundredths of one
 30 per cent. upward) is to improve the malleability of the steel, and in higher proportion it supplements the action of the chromium

and aluminium in imparting hardness to the product.

I claim—

1. As a new article of manufacture, steel containing, in combination with iron, chromium, silicon, and aluminium, the iron being present in greater proportion than the others of said elements, substantially as and for the
 35 40 purposes described.

2. As a new article of manufacture, steel containing, together with iron containing sulphur and phosphorus, substantially as described, chromium, silicon, and aluminium, the iron being present in greater proportion
 45 than the others of said elements, substantially as and for the purposes described.

3. As a new article of manufacture, steel containing, in combination with iron, chromium, silicon, and aluminium in the following proportions: of chromium more than five
 50 one-hundredths of one per cent., of silicon more than five one-hundredths of one per cent., and of aluminium more than five one-hundredths of one per cent., the iron being
 55 present in greater proportion than the others of said elements, substantially as described.

Witness my hand this 15th day of November, 1890.

R. A. HADFIELD.

In presence of—

THOMAS W. BAKEWELL,
 E. M. DAWSON.