UNITED STATES PATENT OFFICE.

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RUST-RESISTING FERROUS ALLOY.

1,317,593. Specification of Letters Patent. Patented Sept. 30, 1919.

No Drawing. Application filed June 3, 1918. Serial No. 237,905.

To all whom it may concern:

Be it known that we, LINWOOD T. RICHARDSON, a citizen of the United States, and ELWOOD A. RICHARDSON, a citizen of the United States, residing, respectively, at Milwaukee, county of Milwaukee, State of Wisconsin, and at Cleveland, county of Cuyahoga, State of Ohio, have invented certain new and useful Improvements in Rust-Resisting Ferrous Alloys; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

Our invention relates to ferrous alloys, and has for its general object the production of an improved rust- or corrosion-resisting ferrous alloy.

In our co-pending application Serial No. 237,904 filed June 3, 1918, we have described a method of improving the rust-resisting properties of iron by adding thereto a major modifying agent and a minor modifying agent whose combined action in minimizing the natural tendency of the iron to oxidize or rust is greater than is the action of either of the modifying agents when used alone. The major modifying agent is that which if alone added to the iron produces the most marked improvement in the rust-resisting properties thereof, while the minor modifying agent is the agent which if alone added to the iron produces some improvement in the rust-resisting properties thereof, but not as great improvement as produced by the major modifying agent acting alone. In this application, we have described the use of copper as the major modifying agent and of manganese and chromium, either separately or together, as the preferred minor modifying agent.

The present invention involves specifically the use of copper and chromium, or of copper, manganese and chromium, as the modifying agents for improving the rust-resisting properties of iron.

In accordance with the principles of our present invention, copper and manganese, operate together to produce a more pronounced improvement in the rust-resisting properties of iron than would be produced by any one of these metals if alone alloyed with iron. We have determined that little improvement in its rust-resisting properties results from the addition of copper to a ferrous alloy containing more than about 2% of chromium, or from the addition of more than 2% of copper to a ferrous alloy of any chromium content. In general, we prefer to alloy with the iron from about 1% to about 2% of copper and from about 1% to about 2% of chromium. Where both chromium and manganese are to be used in combination with from about 1% to 2% of copper, we have found that a combined chromium-manganese content of about 1% to about 2% to produce satisfactory results.

In the preceding paragraph we have mentioned specific percentages which we have found to produce the most satisfactory result in improving the rust-resisting properties of ferrous alloys. We wish it to be understood, however, that we do not intend thereby to limit our invention to the employment of these specific percentages of the modifying agents, since our invention in its broad aspect is capable of advantageous application without particular reference to the specific percentages mentioned. In its broader aspect, our invention thus contemplates the use of from about 1.5% to about 4% of combined copper and chromium, or combined copper, chromium and manganese, each of which is present in quantities from about 0.5% to 2%.

Alloys of iron and copper alone, do not forge satisfactorily. When red hot, such alloys are brittle and smash when struck with a hammer. At low temperatures they can be forged by using extreme care and by expending a great deal of energy. There appears to be a range of temperatures at which any particular copper-iron alloy cannot be satisfactorily worked or forged at red heat. With increasing copper content this "red-short" or non-malleable temperature range occurs at a lower temperature and exists over a longer interval. For example, in the case of one series of copper-iron alloys which we tested, we found that the iron with 0% copper could be forged at all temperatures, with 0.25% copper, the resulting ferrous alloy could not be forged between 940—1010° C., and with 0.5% copper the alloy could not be forged between 890—950° C., while with 0.75% copper, the alloy could not be forged between 850—910° C. This "red shortness", or non-forgeability at red heats, of copper-iron alloys means that these

alloys cannot be satisfactorily forged or worked in a hot state. The presence of chromium, or chromium and manganese, in such quantities as we contemplate for improving the rust-resisting properties of iron, eliminates this non-forging temperature range so that the chromium-copper-iron or chromium-manganese-copper-iron alloy can be worked at all temperatures. The chromium, or chromium and manganese, therefore, has the further function of rendering the ferrous alloy malleable as well as of increasing its resistance to atmospheric corrosion, which function is of great importance in the practical use of the alloy.

While we have thus found that chromium, or chromium and manganese, added in certain percentages to a copper-iron alloy, besides reducing the corrodibility, also enables the alloy to be forged without breaking, we have further determined that the forging of the alloy becomes more difficult if the chromium, or chromium and manganese, content exceeds 2%. Thus, copper-iron alloys containing over 2% of chromium are quite hard when hot, and while such an alloy can be forged without breaking, much more work is required in the forging operation. This means, of course, that in a steel mill a larger amount of work would be required to produce sheets or bars from an alloy containing more than about 2% of chromium than from an alloy containing less than 2% of chromium. The same general rule seems to hold with respect to grinding, filing, and bending. With a chromium content of less than 2% the alloy files and grinds easily and bends readily, while with a chromium content greater than 2% the alloy is more difficult to grind, and is quite tough. These properties, within the range of copper content contemplated by the present invention, appear to be a function of the chromium content, and to be independent of the copper. For these reasons we deem it advisable in the practice of our present invention to use less than 2% of chromium, or combined chromium and manganese, in combination with copper, for improving the rust-resisting properties of iron.

While our present invention is applicable in principle to iron in any of its well known commercial forms, it is particularly applicable to steel and ingot iron because of the ease with which the metallic modifying agents can be added thereto. Thus the copper may be introduced by using pig or cast iron containing the necessary percentage of this metal, or pure copper, or a suitable alloy of copper may be added to the molten iron either in the furnace, in the ladle, or in the molten ingot. The chromium may be added in the furnace or in the ladle as such, or in the form of any suitable alloy thereof. The manganese may be added in conjunction with the chromium or by the use of manganese as a deoxidizer in the refining of the iron. Steel scraps containing chromium or chromium and manganese, may also be used. The essential thing in any case is to get all of the modifying agents into the iron so that they are uniformly distributed.

The matter of costs is of considerable importance in the case of iron or steel for ordinary commercial uses. It is, therefore, important to keep the cost of our improved rust-resisting ferrous alloys as near as possible to the cost of ordinary iron or steel of a corresponding grade. The increased cost of our improved product above ordinary iron or steel of the same grade is due to the required additions of copper and chromium, or of copper, chromium and manganese. As far as possible, therefore, we prefer to use scrap products for the introduction of such additional quantities of these modifying metals as our invention contemplates, and also, where possible, to use materials in the production of the crude or unmodified iron or steel product which contain one or more of the modifying metals in quantities of value in the carrying out of our invention.

Thus, instead of adding copper to the crude iron or steel, it is possible to use an iron ore containing copper, in which case the copper enters the iron or steel in the pig iron obtained in the blast furnace operation. The use of copper-bearing ores probably would not furnish all of the required amount of copper, so that additional amounts would have to be added to the molten iron. Such additions of copper may be obtained from scrap products containing copper, such, for example, as turnings of German silver, Monel metal and the like. Where such copper alloys are employed, it will be evident that metals other than copper may be introduced into the iron, but the quantities in which such other metals are present in the resulting ferrous alloys are relatively small and do not interfere with the effect of the copper, or appreciably alter the properties of the ferrous alloy.

In the smelting of iron ore for the production of the pig iron which later, by remelting, is changed to cast iron, or by remelting and refining, becomes wrought iron, ingot iron or steel, certain impurities in the ore itself, the coke and the slag alloy with the iron. The most common of these impurities are carbon, phosphorus, silicon, sulfur and manganese, since these always occur in the raw materials. In certain ores, other elements exist, and these also appear in the pig iron, such as copper, nickel, chromium and titanium. At the present time, manganese is almost universally used as a deoxidizer of iron, and hence practically all commercial steels contain this element. In the refining process, some of the impur-

ities are oxidized in preference to the iron, and are removed, while with others, the iron is more readily oxidized and hence these latter are not removed, but appear in the final product. To the former class belong carbon, silicon, phosphorus, sulfur and manganese,—while to the latter class, belong copper and nickel. Chromium may be eliminated or not, as desired, depending upon the method used in refining. It may be said then, that commercial iron or steels are in an unstable state as regards corrosion, and by the application of our present invention, a great improvement can be effected in their rust-resisting properties by small changes in the copper-chromium, or copper-chromium-manganese content thereof.

By using ores containing one or more of the modifying metals employed in carrying out our present invention, the cost of making the additions of these metals to the iron is much reduced. Iron ores containing copper and chromium, or only chromium, may thus be advantageously used in the production of our improved rust-resisting ferrous alloy. Take, for example, a well known iron ore containing 1 to 2% of chromium and 1% of nickel. In the smelting and refining of this ore, the nickel will appear in the iron, while the chromium will or will not, depending upon the process used. Here then there exists a raw material which, when used, will give a ferrous alloy containing chromium and nickel, to which copper must be added to produce a rust-resisting iron and to which manganese will probably have to be added as a deoxidizer. This leads to a rather complex ferrous alloy containing chromium, manganese, copper and nickel. The nickel is not added intentionally but gets into the final product because it exists in the ore.

It will thus be seen that our improved rust-resisting ferrous alloy may contain other metals besides copper and chromium, or copper, chromium and manganese, in the percentages which we have found to be of such advantage in improving the rust-resisting properties of the iron. Such other metals are not intentionally introduced, but their presence is due to the raw materials used in carrying out our invention. It will, of course, be understood that by ferrous alloy we mean an alloy containing principally iron, and generally speaking, we may say that our improved ferrous alloy will contain at least 90% iron.

Having thus described our invention, what we claim is:

1. An improved rust-resisting ferrous alloy containing a combined percentage of from about 1.5 to about 4 of copper, chromium and manganese and in which the amount of each of said metals present is from about 0.5% to about 2%; substantially as described.

2. An improved rust-resisting ferrous alloy containing from about 0.5% to about 2% of copper and from about 0.5% to about 2% of chromium; substantially as described.

3. An improved rust-resisting ferrous alloy containing from about 1.0% to about 2% of copper and such a percentage of chromium as to render the resulting ferrous alloy malleable; substantially as described.

4. An improved rust-resisting ferrous alloy containing such a percentage of copper as to render the ferrous alloy when hot substantially non-malleable if alone contained therein, and such a percentage of chromium as to render the ferrous alloy malleable: substantially as described.

5. An improved rust-resisting ferrous alloy containing from about 1.0% to about 2% of copper and from about 1.0% to about 2% of chromium; substantially as described.

6. An improved rust-resisting ferrous alloy containing from about 1.0% to about 2% of copper and from about 1% to about 2% of chromium and manganese combined; substantially as described.

7. An improved rust-resisting ferrous alloy containing such a percentage of copper as to render the ferrous alloy substantially non-malleable if alone contained therein and from about 1% to about 2% of chromium and manganese combined; substantially as described.

In witness whereof we affix our signatures.

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