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NONCORRODIBLE ALLOY ARTICLES AND METHOD OF MAKING SAME

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This application is a continuation in part of my copending application No. 645,637 filed December 3, 1932, and entitled Non-corrosive alloy, and the invention relates to iron-chromium-nickel alloys, and more particularly to corrosion-resisting alloys of the class indicated, and to an art of producing the same.

Among the objects of my invention are the production in a simple, direct and economical manner of a rustless ferrous alloy of a fine even grain which is strong, durable, heat-resistant and corrosion-resistant; one that possesses a high rate of work-hardening, high tensile strength, and good ductility in the work-hardened state; that lends itself to hot and cold working, polishing, and the like; and that is readily riveted or welded in fabrication into desired articles of use.

The invention, accordingly consists in the combination of elements, composition of ingredients, and mixture of materials, and in the several steps and the relation of each of the same to one or more of the others as described herein, and the scope of the application of which is indicated in the following claims.

As conducive to a clearer understanding of certain features of my invention it may at this point be noted that in heretofore known and/or used corrosion-resisting ferrous alloys, either the ferritic rustless alloys of the iron-chromium group or the austenitic iron-chromium nickel groups, many highly desirable characteristics are achieved. These alloys are durable, strong, and tough; they may be worked either cold or hot from strip, sheet or bar stock to give products or articles of desired size and shape; they are resistant to the corrosive effects of atmospheric conditions as well as to many acids, alkalies and salts, and, finally, are resistant to the effects of high temperatures, resisting discoloration and scaling while retaining their physical characteristics, strength, toughness and durability.

In heretofore known and/or used alloys of the class indicated no one alloy, however, is equally possessed of all of the beneficial characteristics outlined above. Thus, for example, an iron-chromium alloy having a chromium content near the lower limit for commercial rust resisting alloys (about 12%) lends itself to both hot and cold working, may be heat-treated to give a fair range of hardness, strength, and impact resistance, and is not particularly susceptible to decarburization and grain growth. The alloy, however, is not qualified for resistance to severely corrosive conditions, for extreme high temperature duty, and especially for high temperatures in corrosive media; which characterizes the iron-chromium alloys of higher chromium contents.

Similarly, an iron-chromium alloy having a chromium content near the upper commercial limit for rustless ferrous alloys (about 27 to 30%) although highly resistant to corrosion, and resistant to discoloration and scaling at high temperatures, suffers in workability and ductility. It does not lend itself to hardening by heat-treatment, and such physical characteristics as tensile strength and impact resistance are limited. It is difficult to machine and must be carefully handled in both hot and cold forming operations to ensure a satisfactory product. It possesses a somewhat coarse grain tending toward growth, under continued use at high temperature thus causing brittleness, low impact, and low fatigue resistance.

Likewise, an iron-chromium nickel alloy, although ductile and workable (both hot and cold), readily weldable and heat and corrosion resistant, is of low tensile strength where the ductility, and consequent formability, is good and becomes objectionably stiff where a desired high tensile strength is achieved.

One of the objects of my invention is the production, in an inexpensive and efficient manner, of a corrosion-resistant ferrous alloy possessing a high rate of work-hardening, and various work-hardened products or articles fashioned of the same, especially cold-rolled and cold-drawn plate, sheet, strip, bars, rods, wire and tubes, of increased elastic limit, for a given amount of work-reduction in area, over heretofore known and/or used products of the character indicated, in combination with good ductility and good formability in the work-hardened condition.

Referring now more particularly to the practice of my invention, to iron, preferably of low-carbon content, there are added the alloying elements chromium and nickel with or without supplementary amounts of molybdenum, tungsten, vanadium, copper and the like, together with small amounts of nitrogen giving a corrosion-resisting ferrous alloy of good hot working and cold working characteristics possessing a high rate of work-hardening.

The proportions of ingredients added are such as to give a ferrous alloy analyzing approximately chromium up to 30%, nickel up to 30%, carbon below .30%, nitrogen between .06% and .20% and the balance substantially iron. Preferably the alloy is essentially austenitic in structure and analyzes approximately 10% to 30% chromium, 5% to 30% nickel, .06% to .30% car-

bon, .06% to .20% nitrogen, especially .09% to .20% nitrogen, and the balance substantially all iron. A typical example analyzes about 18% chromium, 8% nickel, .10% carbon, .10% nitrogen and the balance substantially all iron with the usual small amounts of manganese and silicon. The particular quantity of the alloying metals together with the precise amount of carbon and nitrogen present are largely determinant of the physical characteristics of the alloy as will appear more fully hereinafter.

The properties conveyed by the nitrogen content are in some respects similar to the well known properties resulting from the use of a small increased amount of carbon without, however, the attendant undesirable effects of carbon on corrosion resistance. In addition the presence of nitrogen gives a rate of work-hardening considerably greater than that achieved with carbon. This is an exceedingly important result.

Flowing from the increased work-hardening characteristics are many practical advantages. The metal when cold-rolled into plate, sheet and strip, or when cold-drawn into rods and wire, gives products of greatly increased elastic limits over a carbon bearing alloy of similar chromium and nickel analyses subjected to a like reduction in area. In addition these products are much more ductile in the work-hardened state than heretofore known and/or used cold-rolled chromium-nickel irons and steels of like elastic limits. These products offer a combination of high elastic limit with good ductility in no way realized in heretofore known alloy irons and steels.

Furthermore, the alloy may be bent, pressed, stamped, machined, ground or polished and readily lends itself to fabrication by riveting or welding into a wide variety of ultimate articles of use. In addition, the weld is somewhat harder and is somewhat more reliable than welds achieved in heretofore known alloys of the class indicated.

The hot working characteristics of the metal are not adversely affected by the presence of nitrogen, the alloy lending itself to forging, upsetting, swaging and like hot operations. Similarly, the cold-rolling and cold-drawing are not adversely affected to an appreciable extent. The cold forming characteristics of the plate, sheet and strip, such as beading, spinning and deep-drawing, are but slightly changed for the various chromium and nickel analyses.

Other characteristics of alloys of the class indicated, such as resistance to corrosive effects of acid, alkaline and salt solutions are fully retained and, as a result of the increased work-hardening characteristics of the metal are substantially improved over heretofore known alloys of the kind described where a desired hardness for a permissible reduction in area requires the presence of a considerable amount of carbon, an ingredient having an adverse affect upon corrosion resistance.

Thus it will be seen that there has been provided in this invention an alloy and certain articles and manufactures of the same in which the various objects hereinbefore noted together with many thoroughly practical advantages are successfully achieved. It will be seen that the physical characteristics of rustless ferrous alloys are greatly improved; that these improved characteristics permit many savings in manufacture and use heretofore unrealized; and that the useful field of application of these alloys is appreciably broadened.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiment hereinbefore set forth, it is to be understood that all matter described herein is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In manufactures of the class described, work-hardened alloy iron and steel plate, sheet, strip, bars, rods, wire and tubes, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

2. In manufactures of the class described, work-hardened alloy iron and steel plate, sheet, strip, bars, rods, wire and tubes, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .09 per cent to .15 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

3. In manufactures of the class described, work-hardened alloy iron and steel sheet, strip and bars, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .09 per cent to .20 per cent nitrogen, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

4. In manufactures of the class described, work-hardened alloy iron and steel sheet, strip and bars comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .15 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

5. In manufactures of the class described, work-hardened alloy iron and steel sheet, strip and bars, comprising as essential ingredients approximately, 16 per cent to 20 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .15 per cent nitrogen, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

6. In manufactures of the class described, work-hardened alloy iron and steel sheet, strip and bars, comprising as essential ingredients approximately, 18 per cent chromium, 8 per cent nickel, .10 per cent nitrogen, and the balance substantially iron, said manufactures being hardened throughout by cold reduction, giving desired strength in combination with retained ductility.

7. In manufactures of the class described, cold-rolled alloy iron and steel sheet and strip, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said sheet and strip being hardened throughout by cold rolling, giving desired hardness in combination with retained ductility, and improved corrosion-resistance.

8. In manufactures of the class described, cold-rolled alloy iron and steel sheet and strip, comprising as essential ingredients approximately, 16 per cent to 20 per cent chromium, 8 per cent nickel, .06 per cent to .20 per cent nitrogen, and the balance substantially iron, said sheet and strip being hardened throughout by cold rolling, giving desired hardness in combination with retained ductility, and improved corrosion-resistance.

9. In manufactures of the class described, cold-rolled alloy iron and steel sheet and strip, comprising as essential ingredients approximately, 18 per cent chromium, 8 per cent nickel, .09 per cent to .20 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said sheet and strip being hardened throughout by cold rolling, giving desired hardness in combination with retained ductility, and improved corrosion-resistance.

10. In manufactures of the class described, polished cold-rolled alloy iron and steel sheet and strip, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said sheet and strip being hardened throughout by cold rolling, giving desired strength in combination with retained ductility.

11. In manufactures of the class described, polished cold-rolled alloy iron and steel sheet and strip, comprising as essential ingredients approximately, 16 per cent to 20 per cent chromium, 7 per cent to 15 per cent nickel, .09 per cent to .20 per cent nitrogen, and the balance substantially iron, said sheet and strip being hardened throughout by cold rolling, giving desired strength in combination with retained ductility.

12. In manufactures of the class described, cold-drawn rods and wire, comprising as essential ingredients approximately, 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen, .06 per cent to .30 per cent carbon, and the balance substantially iron, said rods and wire being hardened throughout by cold drawing, giving desired strength in combination with retained ductility.

13. In manufactures of the class described, cold-drawn rods and wire, comprising as essential ingredients approximately, 16 per cent to 20 per cent chromium, 7 per cent to 15 per cent nickel, .09 per cent to .20 per cent nitrogen, and the balance substantially iron, said rods and wire being hardened throughout by cold drawing, giving desired strength in combination with retained ductility.

14. In the production of work-hardened alloy iron and steel sheet and strip of good ductility in combination with desired strength, the art which includes, preparing metal analyzing approximately 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .09 per cent to .20 per cent nitrogen and the balance substantially iron, hot-rolling this metal into plate and sheet, and then cold-rolling these products into sheet and strip apparently effecting a precipitation and dispersion of chromium nitrides throughout the metal giving desired hardness and retained ductility in the work-hardened condition.

15. In the production of highly polished work-hardened corrosion-resistant sheet or strip of good ductility in combination with high strength, the art which includes, preparing metal analyzing approximately 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen and the balance substantially iron, hot-rolling this metal into plate and sheet, cold-rolling these products into sheet and strip apparently effecting a precipitation and dispersion of chromium nitrides throughout the metal giving desired hardness and retained ductility in the work-hardened condition with freedom from decarburization effects, and then polishing the sheet and strip to achieve a desired mirror-like surface.

16. In the production of work-hardened corrosion-resistant rods and wire of high elastic limit in combination with good ductility, the art which includes, preparing metal analyzing approximately 10 per cent to 30 per cent chromium, 5 per cent to 30 per cent nickel, .06 per cent to .20 per cent nitrogen and the balance substantially iron, hot-working this metal into bars, and then cold-drawing these bars into rods and wire apparently effecting a precipitation and dispersion of chromium nitrides throughout the metal and achieving desired strength and hardness with retained ductility.

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