

UNITED STATES PATENT OFFICE

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METHOD OF MAKING DUCTILE IRON-CHROMIUM ALLOYS HAVING A COLD-ROLLED FINISH

No Drawing. Original application filed December 21, 1928, Serial No. 327,750. Divided and this application filed March 30, 1932. Serial No. 602,099.

My invention relates to methods of producing iron-chromium alloy articles containing from 8% to 40% chromium and having a cold rolled finish and a high ductility.

Steel which has been given a cold rolled finish is desired on account of its characteristic bright, smooth and compact surface. It is possible to make ordinary carbon steel and many alloy steels with this kind of a surface finish because the action of the surfacing rolls on the annealed material does not destroy useful characteristics of the steel and because a desired stiffness is imparted to the steel in cold rolling. When iron-chromium alloys containing more than about 8% of chromium, such as stainless steel or rustless iron are given a cold rolling treatment like that given to the carbon steels, the ductility of the material is practically destroyed or is so greatly reduced that the articles have little or no practical utility.

The resistance of these alloys to corrosion depends to some extent upon the physical structure of the alloys. Cold rolling changes the physical structure of the alloys and lowers their resistance to corrosion. The ductility and resistance to corrosion may be restored by annealing but heretofore the characteristics of a cold rolled surface could not be preserved because a thin oxide film was formed which could not be removed without destroying the bright, compact and smooth surface texture.

It is among the objects of my invention to provide a method of producing ductile iron-chromium alloy articles having a cold rolled surface finish and to provide such articles free from surface oxides.

The best cold rolled surfaces are produced if the annealed articles are cold rolled when they are free from oxide. I take the annealed alloy article from which the oxide has been removed by any desired method and give it a cold rolled finish. The rolling reduces its ductility to an undesirable degree. It is then given a heat treatment sufficient to restore the ductility. The treatment may consist of heating to about 600° to 800° C. A short heating such as a minute at this temperature is usually sufficient to restore the

ductility to the cold rolled alloy but a longer heating or a higher temperature may be used in some cases without unduly oxidizing the surface or destroying the finish. However, I prefer to heat the metal at such temperatures and for as short periods of time as will suffice to restore the desired ductility and to form an oxide which can be removed by a method of cleaning hereinafter to be described.

For most purposes, box annealing is used to restore ductility in order to affect the surface as little as possible and to produce a surface oxide of minimum thickness. I have obtained good results in box annealing by heating in a reducing or a non-oxidizing atmosphere which is free from hydrocarbon vapors, or which is at least not strongly oxidizing. The preferred method of box annealing consists in placing a few lumps of wood charcoal in the annealing box out of contact with the metal, heating to about 600° C. and holding the metal at this temperature for about five minutes. A thin oxide is formed on the metal which is practically immune to pickling acids.

To clean the oxide from the article, I use the method described in my co-pending application entitled Method of removing oxide coatings from metals, Serial No. 327,756 filed December 21, 1928. The method consists of treating the metal in an alkali bath which preferably contains an oxidizing agent. The surface oxide is then removed in an acid bath. For the present purposes of illustration, satisfactory results are obtained by using 20% sodium hydroxide solution at about 70° C. in which chlorine has been bubbled until a cloud of oxygen appears in the solution but more or less concentrated alkali solutions, containing from 15% to 30% sodium hydroxide, may be used. Any acid pickling bath may be used which does not attack the metal and destroy the cold rolled finish. A dilute solution of nitric acid makes a satisfactory bath when it is heated to about 70° C. Small additions of hydrochloric acid may be used to advantage with this bath without affecting the surface finish. A bath containing about 3% nitric acid generally

gives the best results but less concentrated acid baths may be used. It is generally advantageous to have not more than 1% hydrochloric acid present when mixed acid is used.

5 For cleaning iron-chromium alloys containing 8% to 20% chromium the concentration of the mixed nitric and hydrochloric acids may be from 1% to 10%. For cleaning
10 rustless iron containing 16% to 18% chromium the best results are obtained by using a 3% nitric acid bath containing less than 1% hydrochloric acid, but with alloys of high chromium content more hydrochloric acid may be used.

15 The following table shows the tensile strength and ductility of three rustless iron articles containing 0.07% carbon and 18% chromium (A) after hot working and box annealing at 800° to 950° C. (B) after pickling and cold rolling and (C) after the cold
20 rolled finish was given to a clean annealed metal article and it was then given a box annealing and cleaning as hereinbefore described.

	Ultimate tensile strength, pounds per square inch	Per cent elongation in 2 inches
30 A. Box-annealed and not cold-rolled	75,000	16
B. Cold-rolled.....	110,000	1
C. Cold-rolled, heat treated and cleaned.....	78,000	17

Comparison of examples A and B shows
35 that cold rolling practically destroyed the ductility of the article. A comparison of examples A and C shows that the finished article produced in accordance with the foregoing description had ductility throughout
40 about the same as a hot worked annealed article of the same composition.

Various modifications of my invention may be made such as removing all the oxide after the article is annealed. Therefore, I
45 desire to be limited only by the prior art and by the invention as defined in the annexed claims.

This application is a division of my co-pending application Serial No. 327,750, filed
50 December 21, 1928.

I claim as my invention:

1. The method of producing a ductile article consisting of an alloy comprising iron and about 8% to 40% chromium which meth-
55 od comprises cold rolling an oxide-free surface, heating in a non-oxidizing or reducing atmosphere to a temperature sufficient to impart ductility to the article, immersing in a solution of sodium hydroxide in the presence
60 of an oxidizing agent, and then in a solution of mixed hydrochloric and nitric acids of a concentration insufficient to destroy the cold rolled surface.

2. The method of producing a ductile iron-chromium article containing about 8% to

20% chromium which comprises hot rolling, annealing, removing the surface oxide, cold rolling so as to give a cold rolled finish, heating to 600° C. to 800° C. to restore ductility to the article, treating at about 70° C. with a
70 15% to 30% caustic soda solution to which a small amount of chlorine has been added and then treating in a dilute solution containing 1% to 10% mixed nitric and hydrochloric acids, said mixture containing not more than
75 1% hydrochloric acid.

3. The method of producing a ductile article with a cold rolled finish consisting of an iron-chromium alloy containing 8% to 40% chromium which comprises cold rolling the
80 article to give it a smooth compact surface-layer, heating in a closed container in the presence of but out of contact with charcoal, said heating being carried on for a time and to a temperature sufficient to restore ductility
85 throughout the article, and then removing surface oxides by immersing in an alkali bath and then in an acid bath of a concentration insufficient to destroy the cold rolled luster which is uncovered by the action of said alkali bath and said acid bath.
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4. The method of producing a ductile article with a cold rolled finish consisting of an iron-chromium alloy containing 8% to 40% chromium which comprises cold rolling the
95 article to give it a smooth compact surface-layer, heating to 600° to 800° C. in a closed container in the presence of but out of contact with charcoal, said heating being for a time sufficient to restore ductility throughout
100 the article, and then removing surface oxides by immersing in an alkali bath and then in an acid bath of a concentration insufficient to destroy the cold rolled luster which is uncovered by the action of said alkali bath and
105 said acid bath.

5. The method of producing a ductile article consisting of an iron-chromium alloy which contains about 8% to 40% chromium which comprises cold rolling an annealed
110 article which is free from surface oxides, heating to temperatures sufficient to restore ductility to the article, said alloy being out of contact with carbon and the atmosphere
115 around the alloy being free from hydrocarbon gases which produce carbon-containing surface layers on the alloy and from oxidizing scale-forming gases, immersing in an alkali solution, and immersing in an acid solution which has a concentration insufficient to
120 destroy the cold rolled finish.

6. The method of producing a ductile article consisting of an iron-chromium alloy which contains about 8% to 40% chromium which comprises cold rolling an annealed
125 article so as to produce a cold rolled finish, heating to temperatures sufficient to restore ductility to the article, said alloy being out of contact with carbon and the atmospheres
130 around the alloy being free from hydrocar-

bon gases which produce carbon-containing surface layers on the alloy and from oxidizing scale-forming gases, immersing in an alkali solution, and immersing in an acid solution which has a concentration insufficient to destroy the cold rolled finish.

7. The method of producing a ductile article consisting of an iron-chromium alloy which contains about 8% to 40% chromium which comprises cold rolling an annealed article so as to produce a cold rolled finish, heating the temperatures sufficient to restore ductility to the article, said alloy being out of contact with carbon and the atmospheres around the alloy being free from hydrocarbon gases which produce carbon-containing surface layers on the alloy and from oxidizing scale-forming gases, immersing in an alkali solution, and immersing in a solution of nitric and hydrochloric acids which contains more nitric than hydrochloric acid and has a concentration insufficient to destroy the cold rolled finish.

8. The method of producing a ductile article consisting of an iron-chromium alloy containing 8% to 40% chromium which comprises cold rolling the article to give it a smooth compact surface-layer, heating to 600° to 800° C. in a closed container in the presence of but out of contact with charcoal, said heating being for a time sufficient to restore ductility throughout the article, and then subjecting the article to an alkali bath to which chlorine has been added and to an acid bath of a concentration insufficient to destroy the finish of the smooth compact surface layer.

9. The method of producing a ductile article consisting of an iron-chromium alloy containing 8% to 40% chromium which comprises cold rolling the article to give it a smooth, compact surface-layer, heating to 600° to 800° C. in a closed container in the presence of but out of contact with charcoal, said heating being for a time sufficient to restore ductility throughout the article, and then subjecting the article to an alkali bath to which chlorine has been added and to an acid bath, containing a dilute solution of mixed nitric and hydrochloric acids of a concentration insufficient to destroy the finish of the smooth compact surface layer.

In testimony whereof, I affix my signature.

HARRY S. GEORGE.

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