

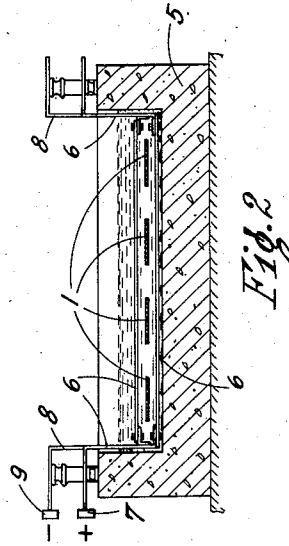
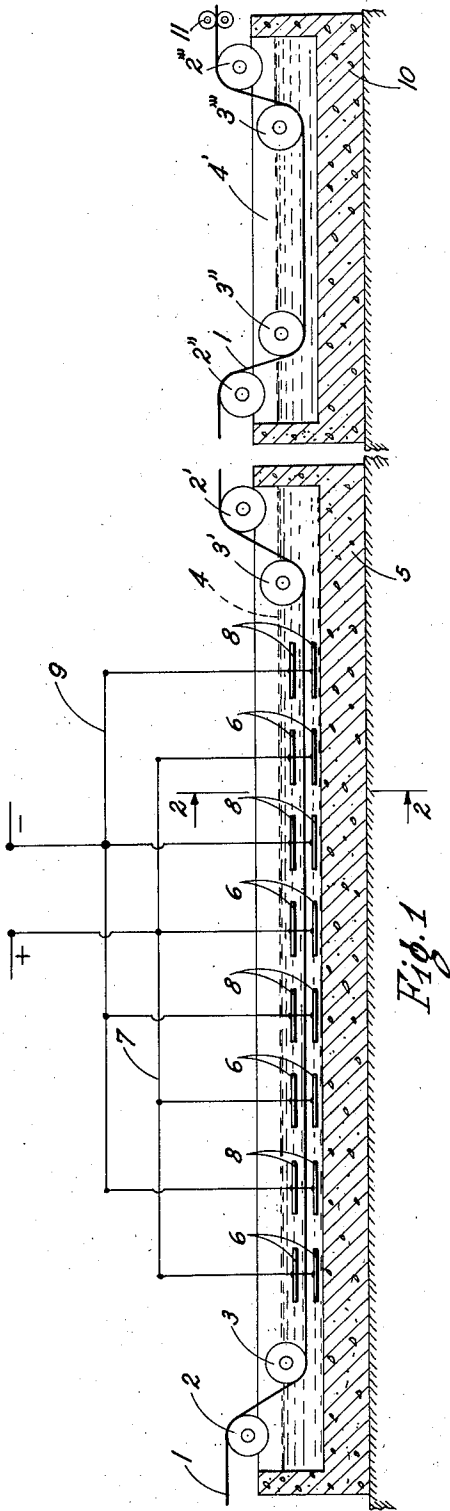
April 14, 1936.

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2,037,633

METHOD OF AND APPARATUS FOR CLEANING STAINLESS STEEL

Filed July 29, 1935



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UNITED STATES PATENT OFFICE

2,037,633

METHOD OF AND APPARATUS FOR
CLEANING STAINLESS STEEL

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Application July 29, 1935, Serial No. 33,727

7 Claims. (Cl. 204—1)

This invention relates to the art of treating metal articles, and more particularly to an improved method of, and apparatus for, removing scale or oxide film from annealed stainless steel strips, sheets and the like.

Considerable difficulty has been experienced in commercially producing stainless steel in sheet or strip form which lends itself to ready polishing. The types of stainless steels particularly concerned are the high chromium steels containing from about 8% to about 40% of chromium, with or without other metals, such as between about ½% and about 30% of nickel.

Such stainless steels are commonly made into sheets, strips and the like, by hot rolling the cast ingot into stock perhaps ¼" in thickness, or even less, after which this stock is cold rolled to the desired thickness or gage. The cold rolling hardens the steel and necessitates one or more annealings of the metal, particularly where the cold reduction is considerable and polished surfaces are desired. For example, when hot rolled stainless steel strips about ¼" in thickness are to be cold rolled to a thickness of 20 gage, the steel is annealed several times during this reduction to remove hardness and restore ductility, and thus to permit further reductions without breakage. It is also desirable to anneal the steel after it has reached its final desired thickness, so that it can be readily handled in subsequent operations or uses.

Much stainless steel in sheet or strip form is used because of the high surface polish which it can take and retain. However, difficulty has been encountered heretofore in preserving the cold rolled surface during the annealing and subsequent pickling operations, because the annealing operation creates an oxide film on the surface of the steel which has heretofore been difficult to remove by pickling. The pickling operation, as carried out heretofore, tends to cause etching of the surface of the steel, thus impairing or destroying the cold rolled finish possessed by the steel before annealing. The oxide or scale on stainless steel resulting from the annealing operation adheres closely to the steel and is difficult to remove. It must be removed in many instances, particularly where a highly polished surface is desired, because this scale and oxide does not take a high polish. It should also be removed where the steel is to be further reduced in thickness to prevent such material from being rolled into the steel.

Many efforts have been made heretofore to remove the oxide or scale from stainless steel resulting from annealing operations, but these processes have not been entirely satisfactory. Where the scale or oxide is non-uniform in thickness, the thinner portions may be removed by pickling before the thicker portions are removed,

with the result that the steel under the thin portions of film may be attacked by the pickling liquid and either etched or roughened to the extent that the cold rolled finish is dulled or largely destroyed.

It has been proposed heretofore to remove such scale or oxide by continuously pickling stainless steel sheets or strips electrolytically by passing the steel thru a sulphuric acid electrolyte while conducting direct current into the steel and then to cathodes in the bath. This process is objectionable because rather high currents are required which necessitate a direct metallic contact between the current conductor and the metal. A sliding or rolling contact is provided, but the danger always exists with such contacts that the current will arc across the space from the contact to the steel, with resultant burning of the surface of the steel and impairment or spoiling of the surface finish.

The present invention avoids all the difficulties of the prior processes, such as etching of the steel in the pickling bath, arcing of the current and the like; it avoids the use of direct metallic contact between a current conductor and the steel; it avoids the danger of "hydrogen hardening" of the steel; and it provides a method of, and means for, alternately subjecting the steel to the anodic and cathodic actions of the current, thus obtaining the benefits and advantages of electrolytic pickling while avoiding its disadvantages. Moreover, the present invention includes the formation of a particular type of scale or oxide film on the stainless steel and a new and novel method and means for removing such foreign materials with the aid of a solution which of itself cannot attack the steel and seriously impair its surface finish.

The accompanying drawing illustrates diagrammatically one form of apparatus embodying the present invention and with which it may be practiced. In the drawing,

Figure 1 is a vertical longitudinal view taken thru a pickling tank, which includes apparatus embodying the present invention and with which a continuously moving wire, rod, strip or sheet of metal may be subjected to the present method.

Figure 2 is a transverse sectional view taken on line 2—2 of Fig. 1.

Altho the illustrated embodiment of this invention is particularly adapted for the removal of scale or oxides from strip steel, it will be understood that this apparatus can be readily adapted for the cleaning of sheets, wires, rods and the like of various cross sectional sizes and shapes. The present invention will be described herein as carried out on strip steel, but the manner of its application to sheets, rods, wire and the like, will be evident to those skilled in the art from the present description.

In Fig. 1, a continuous strip 1 of stainless steel, which has been previously annealed, is passed over a roller 2 and under roller 3 beneath the surface of an electrolyte 4 in tank 5. This strip passes between and in close proximity to, but out of contact with, a series of anodes 6 connected thru leads 7 to a source of direct current and a series of cathodes 8 similarly connected thru leads 9 to the negative side of the said source of current. The strip then leaves tank 5 by passing under a roller 3' and over a roller 2'. Thereafter, if desired, the strip 1 may pass over a roller 2'', under roller 3'' and beneath the surface of liquid 4' in tank 10, thence out of the tank by passing under rollers 3''' and over roller 2''' and between one or more pairs of rubber covered pinch rolls 11 to a winding reel (not shown). The pinch rolls 11 exert tension on and pull the strips thru the furnace and tanks and also expedite drying of the strips by reducing the amount of liquid which is carried therebeyond by the strip. It will be noted that the electrodes 6 and 8 are each arranged in pairs on opposite sides of the strip 1; that the electrodes of each pair are in close proximity to the strip 1; that the pairs of electrodes are separated from each other longitudinally of the tank 5 by distances greater than the distance between each electrode and the strip; and that the anodes 6 and cathodes 8 are preferably alternately arranged lengthwise of the tank. The electrodes of the several pairs are aligned lengthwise of the tank to provide a straight path for travel of the strip between the electrodes of each pair.

For best results the electrodes 6 and 8 should not be susceptible to ready solution or disintegration in the bath. Graphite electrodes flake off rapidly while common steel and stainless steel electrodes are dissolved. Partly treated stainless steel electrodes are better than other steels for electrodes, because they are more resistant to solution in the electrolyte. Lead or lead coated electrodes have given good satisfaction.

The electrodes 6 and 8 may vary in their dimensions taken lengthwise of the tank 5, but preferably are kept below about 12" for larger electrodes in a given length of tank and tend unduly to concentrate the electrodic action on the steel.

The conductors 7 and 9 are so constructed that substantially the same current is delivered to each anode.

The method of the present invention will be clearly understood by those skilled in the art from the following detailed description of it as applied to a continuous strip of stainless steel.

A long strip of hot rolled stainless steel is cold rolled to reduce its thickness. When the steel has hardened, due to the cold rolling, to such an extent that annealing is desirable, the strip is passed endwise thru an annealing furnace, preferably of the muffle type, wherein the steel is heated to the desired temperature, for example, between about 1300° F., and 2000° F., depending on the composition of the steel. Preferably, the strip is welded to the trailing end of a similar strip then being annealed, and in turn its trailing end is welded to the leading end of another similar strip, so that the annealing and pickling operations may be continuous.

The steel strip is heated to the annealing temperature in the furnace, preferably in the presence of highly heated air, i. e., in an atmosphere containing about 19% or more of oxygen. As the strip emerges from the annealing furnace, no

effort is made to protect it from contact with the air nor to retard its rate of cooling.

On the contrary, it is desirable to cool the heavier gage strips, as by spraying water thereon just before the strip enters the tank 5, to reduce the temperature to such an extent that the strip will not unduly heat the electrolyte. The electrolyte temperature should be kept below about 100° F. for the best results. The strip then enters the tank 5 over the roller 2, as has been described, and passes between the electrodes and out of the tank while direct current is flowing in the leads 7 and 9. The current passes from anodes 6 to cathodes 8 by way of the strip 1, for the anodes 6 and cathodes 8 are spaced apart from each other some distance, so that the shortest path, or the path of least resistance, from electrodes 6 to electrodes 8 is thru the strip. As a result, the strip is subjected to the cathodic action of the current while it is between electrodes 6 and to the anodic action of the current while it is between electrodes 8.

It is believed that while the strip is subjected to this cathodic action, the hydrogen generated at the surfaces of the steel has a tendency to reduce the oxide film and that when the strip is subjected to the anodic action between electrodes 8, the film is subjected to the pickling attack of the acid radical in the electrolyte, as well as to the mechanical action incident to the flow of current from the strip to the cathodes 8. Between the electrodes 6 and 8 the strip is subjected to the simple pickling action of the electrolyte. In this manner the steel is alternately and repeatedly subjected to the anodic and cathodic action of the current with intervening pickling action of the electrolyte, (which may be termed non-electrodic pickling) so that the scale or oxide on the surface of the steel is loosened and either removed or converted into a readily removable condition without attendant etching, roughening or pitting of the surface of the steel under the film.

The surfaces of the strip may be scrubbed by brushes or the like with or without washing, after the strip leaves the tank 5. If desired, the strip may be passed thru the pickling tank 10 where it is subjected to the ordinary pickling action, and upon removal therefrom it may again be scrubbed and washed and then dried as by air blasts, if desired. In many instances the use of the pickling tank 10 is unnecessary, but it has been found to be an advantage particularly where a very clean or highly polishable surface is desired.

The preferred composition of the electrolyte in tank 5 is about a 10% solution of a phosphoric acid, i. e., a bath containing about 15% of phosphoric acid by volume. This composition may vary over a considerable range from for example about 8% of acid by volume with stainless steel substantially free from nickel, to perhaps about 20% of such acid by volume with stainless steel containing a higher percent of nickel. It will be understood that as the use of the electrolyte is prolonged the acid content decreases with coincident increase of current required. Near the end of a run the acid content may fall as low as 1% or 2% without harmful results. The higher content is, however, preferred. Other acids which may be used in the bath 5 are: Sulphuric and nitric acid and mixtures thereof. The solution preferred in tank 10 consists of from 5% to 20% by volume of nitric acid with from .1% to about 4% of hydrofluoric acid.

In applying the present process to stainless

steel containing about 18% of chromium and 8% of nickel, for example, with the steel being about .025" in thickness, satisfactory results have been obtained by annealing such a strip at a temperature of about 1900° F., in an open-ended muffle furnace in an atmosphere containing about 19% of oxygen. This temperature was attained in a furnace about 22½ feet long, having a furnace temperature of about 1900° F., with the strip moving endwise therethru at about 6 feet per minute. The strip was permitted to cool in the open air while traversing a space of about 25 feet before it entered the tank 5, at which time its temperature was about 125° F. The tank 5 contained about 10% by volume of orthophosphoric acid, and the direct current passing thru the electrolyte was at about 10 volts and 1000 amperes. About five anodes 6 and about five cathodes 8 were used. After leaving the tank 5 the strip 1 was vigorously brushed by rotating brushes and then was passed thru the tank 10 containing about 15% by volume of nitric acid and 1% of hydrofluoric acid, after which it was again subjected to brushing and washing, and was then dried.

Satisfactory results have also been obtained by the present process on stainless steel substantially free from nickel by similarly treating the steel, except that the annealing temperature attained by the steel was about 1450°, the acid content in tank 5 was about 8% by volume of orthophosphoric acid and the current ranged between about 6 and 10 volts at about 600 to 1000 amperes respectively.

It will be understood that the present process may be employed on steel which has not been annealed. For example, hot rolled, stainless steel strip may be pickled without first going thru the annealing furnace.

Having thus described the present invention, what is claimed is described in the following claims:—

I claim:

1. The process of treating steel which includes the steps of passing cold rolled and annealed stainless steel, having an oxide film on the surfaces thereof, thru an electrolyte containing an acid, passing direct current thru said electrolyte to the steel at a plurality of spaced places along the steel, passing said current from said steel thru the electrolyte at a plurality of other places spaced apart along the steel and intermediate the first said places, and exposing the steel to the non-electrode pickling action of the acid in the electrolyte between said spaced places.

2. The process of treating steel which includes the steps of passing cold rolled and annealed stainless steel, having an oxide film on the surfaces thereof, thru an electrolyte containing a dilute acid, passing direct current thru said electrolyte and to the steel at a plurality of places on opposite sides of the steel, passing said current from said steel thru the electrolyte at a plurality of other places on opposite sides of the steel spaced apart along the steel and intermediate the first said places, and exposing the steel to the non-electrode pickling action of the acid in the electrolyte between said spaced places.

3. The process of treating steel which includes the steps of passing cold rolled and annealed stainless steel, having an oxidized surface, thru

an electrolyte containing between about 8% and about 20% of phosphoric acid by volume, passing direct current of between about 6 and about 12 volts at between about 600 and about 1200 amperes thru the electrolyte to the said oxidized surface of the steel from a plurality of anodes spaced along the path of travel of the steel, conducting current from the oxidized surface of said steel thru the electrolyte to a plurality of cathodes arranged between but spaced apart from said anodes along said path of travel, exposing the steel between the alternately positioned anodes and cathodes to the non-electrode pickling action of the acid and thereafter removing loose particles of foreign material from the said surface of said steel, whereby the thus treated steel possesses substantially the surface it possessed in cold rolled but unannealed state.

4. The process of treating steel which includes the steps of cold rolling stainless steel thereby giving it a polished surface, annealing said steel in an oxidizing atmosphere thereby forming an oxide film on the polished surface thereof, and then removing said film without altering substantially the cold roll surface by subjecting the steel repeatedly to the anodic and cathodic actions of direct current in an electrolyte containing acid, repeatedly subjecting the steel to the non-electrode pickling action of the acid between said electrode treatments, mechanically scrubbing the steel, and washing and drying it, whereby, after such treatment, the steel possesses substantially the cold rolled finish it possessed after the cold rolling and before the annealing.

5. The process of treating steel which includes the steps of passing stainless steel, having an oxide film on the surface thereof, through an electrolyte containing an acid, passing direct current to and from the steel through the electrolyte at a plurality of alternately arranged spaced places along the steel, and exposing the steel to the non-electrode pickling action of the acid between said spaced places.

6. The process of treating steel which includes the steps of passing steel, having an oxide film on the surface thereof, through an electrolyte containing an acid, subjecting the steel to the cathodic action of a direct current at a plurality of places spaced along the steel, subjecting the steel to the anodic action of a direct current at a plurality of other places spaced along the steel between the first said places, and exposing the steel to non-electrode pickling action of the acid between said places where the steel is subjected to the anodic and cathodic action of the direct current.

7. The process of treating steel which includes the steps of passing stainless steel in thin elongated form and having an oxide film on the surfaces thereof, through an electrolyte containing an acid, subjecting opposed surfaces of the steel at a plurality of places spaced along the steel to the cathodic action of a direct current, simultaneously subjecting opposed surfaces of the steel at a plurality of other places spaced along the steel to the anodic action of a direct current, and simultaneously exposing the steel between the said places subjected to such cathodic and anodic action to non-electrode pickling action of the said electrolyte.

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