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METHOD OF ELECTROPOLISHING STEEL

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This invention relates to a method of electropolishing steel and more particularly to the anodic treatment of plain carbon and low alloy steels to impart thereto a lustrous, mirror-like polish.

It has heretofore been common practice to polish steel by a mechanical operation, either on automatic polishing and buffing machines, or manually, or by a combination of automatic and manual operations. In addition to the considerable cost of mechanical polishing, particularly where some of the polishing operations have to be performed manually, there are some drawbacks in the mechanical polishing of steel which are inherent because of the properties of the metal itself. High speeds of polishing, which might be attempted with power driven polishing equipment, tend to burn the surface and hence greatly limit the speed at which polishing can be performed. Commercially mechanically polished steel is also marked by microscopic scratches and the surface has a tendency to "pile" so that it is cold worked and strained. This condition is not conducive to the obtaining of a good metal electrodeposit over the polished surface.

While electrolytic methods for the cleaning or etching of steel are well known, such methods have not, to the best of my knowledge, been capable of producing highly polished surfaces. The patent to Burns et al. No. 1,658,222, dated February 7, 1928, for instance, refers to the anodic electrocleaning of ferrous metals preparatory to nickel plating, and alleges that a "smooth, polished and uniformly etched surface" may be produced by an electrochemical cleaning action using a bath of highly concentrated phosphoric acid. By following the procedure disclosed in this patent, however, I have been unable to obtain a brightly polished surface, but merely a surface that is somewhat brighter than that obtainable by the usual pickling processes. Actual comparative tests of the reflective powers of steel samples electrolytically polished in accordance with the Burns et al. and my methods show that steel polished by the method herein described has 10 times the specular reflectivity of the Burns et al. steel and that the Burns et al. steel has from 20 to 30 times more diffuse reflectivity.

Similarly, although the Blaut et al. Patent 2,115,005, dated April 26, 1938, purports to describe an electrochemical cleaning process that will produce a "burnished" surface, I have been unable to obtain, following the procedure of that patent, such a highly lustrous polish on steel as is readily produced by the use of the electrolytic solution used in my present method.

I have now found that through the use of an electrolytic solution comprising sulfuric, phosphoric and chromic acids of relatively high combined acid concentrations a superior polishing

effect may be produced more readily and at a lower cost than was heretofore possible. This type of electrolytic solution is particularly applicable to the polishing of plain carbon steels and steels having a total of not over 6% of alloying ingredients. The Blaut et al. patent does not suggest the possibility of polishing plain carbon or low alloy steels.

It is therefore an important object of my invention to provide an electrolytic method for polishing steels, particularly of the plain carbon and low alloy type, to impart thereto a highly lustrous surface directly and without the need of subsequent mechanical polishing operations.

It is a further important object of my invention to provide a method of electropolishing steel to produce thereon surfaces that are highly lustrous and free from the scratches and "pile" layers characteristic of mechanically polished surfaces.

It is a further important object of this invention to provide a method of electropolishing steel that can be carried out at a cost considerably less than that entailed by mechanical polishing operations, while at the same time producing surfaces having relatively superior characteristics to those obtainable by mechanical polishing.

It is a further important object of this invention to provide an effective method of electropolishing steel to impart a high lustre thereto, such that no further treatment will be necessary in preparing the surface for an electroplating operation, such as bright nickel plating.

Other and further important objects of this invention will become apparent from the following description and appended claims.

The method to which this invention pertains involves making the steel to be polished the anode in an electrolytic bath of suitable composition and passing a current of sufficient density and for a sufficient length of time through the bath to produce a high lustre or polish on the steel. By employing an electrolytic solution of the composition hereinafter described, results are obtained that transcend the mere electrolytic cleaning process, in that there is produced a highly lustrous or polished surface. This high lustre is an important feature of my invention and one that sharply distinguishes it from prior art finishes produced in the electrolytic cleaning of metals.

The electrolytic solution that I have found to possess the most general effectiveness in the polishing of steels comprises a mixture of sulfuric, phosphoric and chromic acids in such proportions that the combined acid concentration is at least 50%, and preferably over 60% by weight of the solution, the balance being mainly water. While it is possible to produce polishes with mixtures of sulfuric, phosphoric and

chromic acids containing as much as 50% water, I prefer to keep the water content of the electrolytic bath relatively low, since I have found, in general, that baths containing lower proportions of water may be operated at lower current densities, and therefore at lower cost, to give satisfactory polishes. I therefore prefer to have the total acid content kept within the range of 60 to 90%, the balance being mainly water. Both the sulfuric and phosphoric acid concentrations should be in excess of 5%, with an upper limit of concentration for each of about 80%, although the upper limit is not critical and might be exceeded except for practical reasons. Preferably, the sulfuric acid concentration should be between 15 and 60% and the phosphoric acid concentration between 15 and 70%.

The addition of chromic acid to the sulfuric-phosphoric acid solution greatly increases the polishing effect toward steels, and I prefer to add chromic acid in substantial amounts up to about 20%, although as low as 0.5% chromic acid gives noticeably improved results over those obtained without any being present in the sulfuric-phosphoric acid mixture. From 2 to 10% chromic acid, from 15 to 20% sulfuric acid and from 63 to 67% ortho phosphoric acid represents a narrower, preferred range for my bath composition.

Unless otherwise specified, all percentages referred to herein will be understood to represent percentages by weight, rather than by volume. Also, the terms "sulfuric acid", "phosphoric acid," and "chromic acid" refer to the respective acids of 100% strength, rather than to any particular commercial strength. By "chromic acid" is meant the anhydride of the formula CrO_3 .

In order to obtain the desired results in a reasonable length of time, I prefer to use relatively high current densities in my electropolishing method. With the preferred bath composition, the process can be operated with anode current densities varying from 50 to 1000 amperes per sq. ft., but preferably between 100 and 400 amperes per sq. ft. It will be understood that even lower current densities may be employed, but longer times of treatment will be required and the process may, for that reason, be uneconomical. Higher current densities than indicated by the foregoing range may also be employed, but in that case the higher current costs offset the saving in time. The length of time to effect the desired results depends upon the magnitude of the current densities employed, and to some extent upon the particular metal to be polished and the character of its surface initially. Rough surfaces, of course, require a longer time to polish than relatively smooth ones.

The mechanism by which the highly polished and lustrous surfaces characteristic of my invention are produced is not well understood, but is undoubtedly associated with the presence of a polarizing film over the surface of the steel during the process of anodic attack. The nature of this film is such that selective attack of the various phases present in the metal is minimized. Anodic dissolution apparently takes place at a relatively high rate at high anodic polarization values. The result of the anodic dissolution of the metal under these condition is to level the crystal surfaces of the steel and to produce a smooth and mirror-like finish. These condi-

tions do not prevail in the simple electrolytic cleaning treatments known to the prior art.

The following examples will serve to illustrate preferred compositions of my electrolytic solutions and the conditions under which such solutions produce satisfactory polishes on steel, and particularly ferritic steels.

EXAMPLE 1

Bath composition

	Per cent
Sulfuric acid.....	15
Ortho phosphoric acid.....	63
Chromic anhydride.....	10
Water	12

This electrolyte produces mirror-like polishes on ordinary low carbon steel when it is treated anodically therein at current densities of 100 to 400 amperes per sq. ft. for 20 to 90 minutes at temperatures in the neighborhood of 50° C.

EXAMPLE 2

Bath composition

	Per cent
Sulfuric acid.....	20
Ortho phosphoric acid.....	67
Chromic anhydride.....	4
Water	9

This solution produces mirror-like polishes on ordinary high carbon steels when such steels are treated anodically therein at current densities of 100 to 400 amperes per sq. ft. for 20 to 90 minutes at bath temperatures in the neighborhood of 50° C., employing any suitable inert cathodes.

EXAMPLE 3

Bath composition

	Per cent
Sulfuric acid.....	20
Ortho phosphoric acid.....	67
Chromic anhydride.....	2
Water	11

A bath of the foregoing composition produces an excellent polish on a steel containing 0.5% of molybdenum, when the steel is treated anodically therein at anode current densities of 250 amperes per sq. ft. for 30 minutes at a bath temperature of 50° C. A bath of the same composition is also applicable to the electropolishing of 5% chromium steels and to copper steels containing 0.25% copper and above.

EXAMPLE 4

Bath composition

	Per cent
Sulphuric acid.....	40
Ortho phosphoric acid.....	44
Chromic acid.....	6
Water	10

EXAMPLE 5

Bath composition

	Per cent
Sulphuric acid.....	60
Phosphoric acid.....	15
Chromic acid.....	10
Water	Balance

My method is generally applicable to steels, but particularly to those classed as plain carbon steels and to low alloy steels having not more than 6% of combined alloy content. With such steels I am able to produce a surface which is

unique, in that it is free from the amorphous or worked layer characteristic of mechanically polished steel and which is also free from the microscopic scratches present on the surfaces of such steel when polished by any commercial process. In using the term "amorphous" as descriptive of the layer present on the surface of such steels, I am well aware of the controversy that has been waged over the nature of this layer and of the fact that the word "amorphous" may not be truly descriptive of the layer. The existence of a layer of worked material is, however, admitted by authorities and its absence on steel polished by my method contributes, I believe, to the superior characteristics of the electropolished surfaces.

Steel treated by my process presents a level surface of the crystals composing the metal, and as a result of this, a high lustre or mirror-like finish, unmarred by scratches and by the presence of an amorphous or worked layer. Surfaces that have been electropolished in accordance with my method are more amenable to good electroplating than a mechanically polished surface and are also more resistant to corrosion.

Electropolished surfaces produced by my method are likewise different from those made by the electrolytic treatments of the prior art. The application to steels of methods heretofore used generally results in surfaces which are characteristically etched. The crystals in the metal are strongly developed and placed in relief, so that while the surface may be bright, it is essentially a matt finish. By the use of my method, however, the development of the crystalline structure is suppressed, the surfaces of the individual crystals are levelled off, the grain boundaries are substantially obliterated and there results a smooth and mirror-like finish.

From the foregoing description of my invention it will be apparent that I have provided a novel and effective method for the production of highly polished, lustrous surfaces on steels. My method avoids the disadvantages of the old methods of mechanical polishing and enables the production of surfaces which are free from worked material and which are not marred by scratches.

This application is a continuation-in-part of my application Serial No. 241,975, filed November

23, 1938, and entitled "Electrolyte for the polishing of metal surfaces."

It will, of course, be understood that various details of the process may be varied through a wide range without departing from the principles of this invention, and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. The method of electro-polishing steel selected from the group consisting of plain carbon and low alloy steels, which comprises making the steel the anode in an aqueous solution of from 5 to 80% of sulfuric acid by weight of said solution, from 5 to 80% of phosphoric acid by weight of said solution and from 0.5 to 20% of chromic acid by weight of said solution, the combined acid concentration being above 50% but not over 90% by weight of said solution, the balance being essentially water, and passing therethrough an electric current of a density between 50 and 1000 amperes per square foot.

2. The method of electro-polishing steel selected from the group consisting of plain carbon and low alloy steels, which comprises making the steel the anode in an aqueous solution of from 15 to 60% of sulfuric acid by weight of said solution, from 15 to 70% of phosphoric acid by weight of said solution and from 0.5 to 20% of chromic acid by weight of said solution, the combined acid concentration being above 50% but not over 90% by weight of said solution, the balance being essentially water, and passing therethrough an electric current of a density between 50 amperes and 1000 amperes per square foot.

3. The method of electro-polishing steel selected from the group consisting of plain carbon and low alloy steels, which comprises making the steel the anode in an aqueous solution of from 15 to 20% of sulfuric acid by weight of said solution, from 63 to 67% of phosphoric acid by weight of said solution and from 2 to 10% of chromic acid by weight of said solution, the balance being essentially water, and passing an electric current therethrough of sufficient density and for a sufficient length of time to produce a polish on said steel.

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