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2,915,444

**PROCESS FOR CLEANING AND PLATING  
FERROUS METALS**

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No Drawing. Application December 9, 1955  
Serial No. 551,977

19 Claims. (Cl. 204—145)

This invention relates to a process for removal of foreign matter, particularly rust and scale from the surfaces of ferrous metals. It is particularly applicable to the derusting of high and low carbon steels and functions with equal facility for the treatment of cast iron and malleable iron.

Conventional methods of pickling ferrous metals involve treatment with acids wherein the base metal is subject to attack as well as the products of corrosion on the surface of the metal. Acid pickling will likewise deteriorate nonferrous coatings on iron and steel when rust removal from such surfaces is done. Another shortcoming inherent in automatic plating operations involving acid pickling is the strong tendency of the work to rust after pickling and before metal deposition. Prior attempts at nonacid pickling have been slow, tedious and only partly successful. This application is a continuation-in-part of application Serial No. 323,696, filed December 2, 1952, now abandoned.

A primary object of this invention is to provide a process which will selectively remove rust from the surfaces of ferrous metals without action whatsoever on the base metal.

Another object is to provide a process for accomplishing cleaning and rust-removal from ferrous metals in a single operation.

Another object is to provide a process for the alkaline cleaning and derusting of ferrous metals which eliminates the objections inherent in acid-pickling operations.

I have discovered a process where, in the presence of certain complexing and chelating agents, foreign matter, including rust, dirt, scale, grease, and the like, are rapidly removed from the surfaces of the metal while passing a current through an alkaline solution of the complexing agent at a pH of 10.0 or greater while the articles treated are made the cathode.

The invention is valuable for a variety of metal-treating operations. For example, it is suitable for removing the oxides from ferrous metal articles including, with or without the aid of a supplemental treatment, heavy electrically conducting deposits and scales of black oxide of iron. It removes rust from iron and steel plated or otherwise coated with another metal, such as steel electroplated with nickel, chromium, silver, zinc, cadmium and tin without significantly dissolving the plate or coating. It can be used to clean molds, such as molds for rubber articles, plastic articles, etc., stripping off remnants of the rubber, plastic, etc., left on them. It also strips paint, resins, and varnish, and removes oil, grease, carbon, smut, and superficial dirt. It is suitable for cleaning off oil and grease, etc., and for deoxidizing ferrous articles in preparation for further treatment, such as painting, phosphating, electroplating, etc., in a single operation in most instances as contrasted with the two operations now commonly employed, one for cleaning and another for removing rust and scale, and also to do so without attacking the underlying metal

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as the acid pickles tend to do. However, it is not well applicable to stainless steel for this latter purpose.

Solutions of this invention are vehicles from which various metals, such as zinc, cadmium, silver, copper, iron and tin can be electroplated out and these solutions also accomplish cleaning and deoxidizing.

For example, solutions of this invention can be used for cleaning, oxide removal and plating whereby the article to be treated is immersed in one solution in contrast with three or more solutions normally required. A ferrous article coated with grease and rust when immersed in solutions of this invention can be seen to first have the grease removed. Following this the oxide is removed and as soon as oxide has been removed, the metal will plate out. Considerable practical use has resulted from this invention for plating of articles difficult to rinse, such as large cylinders with small openings.

In accordance with the invention, I have discovered that ferrous metals can be cleaned of oils, grease, and the like, deoxidized, and stripped of nonmetallic coatings by subjecting the articles to electrolysis in a strongly alkaline aqueous solution of a water-soluble complexing or chelating agent for iron oxides, while the articles are made the cathode for at least part of the time during electrolysis. An alkylolamine, such as triethanolamine, will function effectively as the complexing agent or can be preferably employed to augment the action of other complexing agents through its ability to solubilize the iron in the high pH range. The addition of an alkaline cyanide salt to the solution tends to speed the effective action of the solution containing the complexing agent. The operation may be at room temperature, although elevated temperatures appear to accelerate the rate of reaction. Various metals, for example such as those mentioned above, are soluble in the solution, and when present may be electroplated out onto the articles; the invention can be used solely for cleaning and deoxidizing or jointly for cleaning, pickling, and/or stripping and electroplating so that a ferrous article can, at the same time, be prepared for electroplating, and then electroplated in a single continuous operation. When black oxides of iron, such as heat treat scale, composed of  $Fe_3O_4$  are to be removed, it has been found advantageous to make the article alternately the anode and then the cathode, whereas, when the oxide is non-conductive ferric types of oxide, best oxide removal is accomplished by making the work the cathode solely.

The operation seems to dissolve the ferrous and ferric oxides, and its action in removing these oxides as well as light greases, oils and superficial dirt is remarkably rapid, a matter of seconds or a few minutes, depending upon the current density employed. With most articles, therefore, a single treatment with the present invention is sufficient for complete cleaning.

The complexing or chelating agents used in the practice of the invention may be selected from a large class of water-soluble organo hydroxy, organo amino and amino hydroxy compounds found to be effective within the specified conditions of alkalinity, and while the iron and steel articles are made the cathode during treatment. Preferably, the complexing agents are organic compounds provided with at least two hydroxyl or amino groups or one hydroxyl and one amino group adjacently located in the molecule to produce a complex or chelate ring with ionic iron in the form of ferrous or ferric oxides, while not affecting the underlying molecular iron. Whether this action actually occurs during the course of the reaction and under the conditions specified, or whether the agents merely combine with the ferrous and ferric ions in some other manner, is immaterial to a definition of the invention which operates successfully

for the cleaning and derusting of the ferrous articles under the specified conditions.

Among the complexing agents suitable for the practice of the present invention, the following groups of derivatives have been found to operate successfully under the conditions of high alkalinity and while the ferrous articles are maintained the cathode for at least a portion of the treatment:

(1) Open chain polyhydroxy compounds with hydroxy groups in 1, 2 or 1, 3 positions, preferably the 1, 2 positions, such as ethylene glycol, propylene glycol as well as polyol compounds, including glycerine, mannitol, sorbitol, fructose, sucrose, glucose, and starches.

(2) Hydroxycarboxylic acids containing at least two hydroxy groups one of which is spaced no further than the beta position from the carboxyl group. These compounds include such materials as glyceric, saccharic, tartaric, and gluconic.

(3) Amino carboxylic acids where the amino grouping is in the alpha or beta position such as glycine, alanine and betaalanine.

(4) Diamines where the amino groupings are on adjacent carbons or on carbons in the 1 and 3 positions. These include ethylene diamine, propylene diamine, diethylene triamine and other condensation products of ethylene diamine.

(5) Acetic acid substituted ammonia compounds, such as ammonia diacetate and ammonia triacetate.

(6) Ethylene diamine diacetic acid salts, ethylene diamine triacetic acid salts and ethylene diamine tetraacetic acid salts. They also include compounds where one or more of the acetate groupings is replaced with an ethanol grouping, such as hydroxyethyl ethylene diamine triacetic acid salts, and dihydroxyethyl ethylene diamine diacetic acid salts.

(7) Hydroxyamino compounds or alkylolamines, such as ethanolamine, diethanolamine, triethanolamine and corresponding propanolamines, as well as related compounds such as aminoethylethanolamine.

For cleaning and deoxidizing, the solution consists essentially of the reaction products of the following agents in aqueous solution per liter of solution:

An alkali hydroxide or hydroxides, for example sodium hydroxide or potassium hydroxide or a mixture of these two, sufficient in quantity to give the ultimate solution a pH above ten (10), and preferably higher. By weight there may be, say, from five (5) grams to four hundred (400) grams. The maximum permissible quantity however is that which leaves the solution with only sufficient solubility to dissolve sufficient of the other active agents. Preferably I use between twenty-five (25) and two hundred (200), and ordinarily about one hundred twenty (120) grams, this being about an optimum value considering the optimum concentrations of the other active agents.

Iron ion complexing agent, from about five (5) grams to saturation. Its preferred range appears to be from about thirty (30) grams to 120 grams.

One or more alkali cyanides (such as, for example, sodium cyanide or potassium cyanide), from none at all to saturation. About one hundred twenty grams (120) is a suitable concentration.

Water sufficient to make one liter of solution.

The bath or solution can be formed by dissolving in water such of the foregoing agents or equivalents of them as may be desired in any instance. The iron ion complexing agents are readily soluble either in water at room temperature or in the alkaline solution having a pH of at least 10.0. In the case of carboxylic acid complexing agents, the alkali salts are readily soluble in water, whereas, the acids themselves are directly soluble in the alkali solution. It is usually more convenient where possible to use the iron ion complexing agent in the form of its salt. Also, the TEA is an oily liquid which is hygroscopic, while its hydrochloride

is a dry powder. For this reason, I may prefer to use the hydrochloride form rather than the liquid.

However, the two, three or four of such active ingredients (i.e., however many may be used in any instance) may be mixed in the form of dry powder (the TEA being in the form of the hydrochloride), and stored in this form. The relative proportions of the active agents or ingredients comprising the dry composition may be various of course, just as in the case of a solution and as appears above. A suitable mixture of this form is, the proportions being by weight; sodium hydroxide, thirty-six (36) parts; iron ion complexing agent, thirty (30) parts; and sodium cyanide, thirty-four (34) parts. A cleaning and pickling solution containing about such optimum concentrations of the active constituents can be made by dissolving from about fifty (50) grams to about four hundred (400) grams of such a mixture, preferably about three hundred sixty (360) grams, in sufficient water to make one (1) liter of solution.

As before indicated, the cleaning operation in the ordinary case, e.g., when the oxides present are mostly the ferric oxides, such as heavy rust, may consist only of subjecting the piece or article to electrolysis for some seconds or a few minutes in a solution of the nature indicated above, the piece or article being the cathode of the cell for at least a part of the time. However, when the oxide is heavy and its pores filled with oil, the action of the electrolysis tends to be somewhat slower, and then can be speeded up by precleaning to remove the oil or grease. Any ordinary cleaning operation that is sufficient for such work is satisfactory for the present purposes; it may be, for example, simple soaking in solvents, or vapor degreasing, or electrolytic alkali cleaning, and I prefer anodic alkali cleaning. Also where considerable black oxide ( $Fe_3O_4$ ) is present, including welding and heat treatment scale, or where nonporous coatings of paint or other nonmetallic coatings are continuous over substantial parts of the area to be cleaned, the piece or article can well be treated, or even may need to be treated to break up the continuity of the foreign matter and give the present solution access through them. For example, some parts scaled by heat treatment can be descaled successfully by the present operations if first they are soaked in a strong acid, e.g., hydrochloric acid or sulphuric acid, for a few minutes; for example, in 25% to 50% commercial hydrochloric acid for from one to five minutes. The acid soak renders the scale porous and thus permits the solution to penetrate it. Again, continuous areas of paint, etc., may be broken up mechanically, e.g., by tumbling in a barrel, with or without the aid of steel balls, by flexing, and the like.

For the electrolysis, the anode or anodes are made of carbon by preference, since anodic action in the present solution dissolves most metals, and additionally the dissolved metals may plate out onto the article being treated.

The bath temperature may be substantially any readily available temperature, that is to say from about 60° F. to the boiling temperature of the solution. Speaking generally, the higher the temperature, the more rapid is the deoxidizing and cleaning operation, but also the greater the tendency for the bath or solution to break down, and this is especially true when cyanide is present in the solution. Preferably, I do not exceed 130° F.; a temperature of 120° F. is quite satisfactory, in most instances at least; even at this latter temperature there is some decomposition of the bath due to temperature, and longer life is obtained by running the solution from 70° to 100° F. Insofar as may be necessary or desirable, the bath can be heated by immersion electric heaters or otherwise of course, as will be understood from electroplating practices. However, the current flow tends to heat the bath, and at high current densities it may be necessary to cool the bath by cooling coils or otherwise to prevent the temperature rising above a desired value.

The current density, i.e., the current density at the

area or areas of the work being treated can vary between wide limits, e.g., from say one-tenth (0.1) ampere per square foot to a thousand or more amperes per square foot. Speaking generally, the higher this current density the more rapid is the cleaning, deoxidizing and stripping action. On the other hand, the higher the current density the higher tends to become the temperature of the bath or solution, and as before pointed out it is not desirable that the temperature become extremely high. All things considered, I usually use a current density, at the piece or article being treated, of less than about one hundred (100) amperes per square foot, and customarily about fifty (50) amperes per square foot is satisfactory.

For the removal of rust (ferric oxide) for example, the current may be direct current, the piece or article being treated being the cathode of the electrolytic cell for the entire period of the electrolysis. By reversing the direction of the current flow occasionally however, so that the work, i.e., the piece or article being treated, is made the anode occasionally or periodically, the attack may be made somewhat heavier and the operation brought to completion somewhat more quickly, especially when the oxides, scales and other foreign matters are those which are not so readily and directly affected by cathodic treatment. Alternating current of the common commercial frequency (60 cycles per second) may be used, but frequencies lower than this are preferable, and in fact down to very low frequencies of ten (10) cycles per minute or less. Also, nonsymmetrical reversals may be found preferable to symmetrical in some instances, depending on the nature of the foreign matter to be removed and the base metals. During the anodic periods, the operation removes surface smut and also seems to cause pores in and undermine the foreign matters, thereby giving the solution access to and underneath the foreign matters during the cathode periods. The relative lengths of the cathode periods and the anodic periods may be selected with this in mind; i.e., the less effective the cathode action in any instance, the longer to be the time periods chosen for the anodic action. Such periodic reversals that the work is the cathode for periods of about thirty (30) seconds each and the anode for periods of about ten (10) seconds each, is quite effective usually.

So far as concerns maintenance of the solution, such of the iron as is taken into the solution is readily disposed of. The dissolved iron may be plated out either automatically as it were, during the course of and as an incident accompanying the deoxidizing, or as it were by extending periods of deoxidizing a little. When the cyanide is present, accumulating iron is precipitated as an iron cyanide complex. Excepting for such loss of cyanide, the principal loss of solution and its active agents seems to be that which occurs through drag-out, leakage, spray and the like. In maintaining the solution therefore, the solution may be analyzed occasionally for cyanide, and the cyanide replaced as may be necessary to keep the cyanide concentration within an effective range; the range being a rather wide one, as appears above, this can be done readily and without an undue amount of attention. As to the remainder of the active agents, it is necessary only to analyze the solution for, say, the hydroxide occasionally and replace as necessary to maintain the hydroxide concentration within the range selected for it, and at the same time, i.e., whenever replacing hydroxide, add more complexing agent, and in say, the same relative proportions as were used in making up the original mixture. Water may be added as necessary to maintain an adequate volume of the solution.

#### Example I

A simple example of deoxidizing will serve to illustrate the foregoing. Assume that a cast iron piece has a heavy thick coating of black oxide, perhaps with a material amount of adsorbed oil: If desired, the piece may be cleaned in any simple way to remove superficial dirt,

loose rust, etc. such as vapor degreasing the piece until free of oil. Then immerse in an alkaline aqueous solution previously made from a dry mixture containing sodium hydroxide, thirty-six (36) parts, tetrasodium salt of ethylene diamine tetraacetic acid, fourteen (14) parts; TEA hydrochloride sixteen (16) parts; and sodium cyanide, thirty-four (34) parts, using about three hundred sixty (360) grams of the mixture for each liter of the solution.

Using the piece as one electrode and a piece or pieces of carbon as the other electrode, apply current to bath at such a voltage that the current density at the piece being treated is about fifty (50) amperes per square foot. Reverse the direction of the flow of the current repeatedly so that the piece being treated is the cathode of the cell for periods of about thirty (30) seconds each and is the anode for intervening periods of about ten (10) seconds each. By heating or cooling, maintain the temperature of the bath about 120° F.; unless the volume of the bath is large relative to the size of the piece being treated, probably this will require the bath to be cooled. Continue this treatment until the surface of the piece is completely freed of the oxide, or freed of the oxide to such an extent as may be desired; complete freeing of the oxide may take from two (2) minutes to as much as fifteen (15) minutes if the scale is dense and deep; or possibly up to thirty (30) minutes. When the action is completed, remove the piece from the solution and rinse thoroughly in running water. If desired, the surface of the piece can be neutralized by then dipping in an acid solution, say an aqueous solution of about seven and one-half (7.5) grams of chromic acid (CrO<sub>3</sub>) per liter of water, and then rinsing again in water.

#### Example II

In a similar procedure, rusty steel was made the cathode in a bath containing sodium gluconate as the iron complexing agent, one hundred (100) grams per liter; sodium hydroxide, two hundred (200) grams per liter at a temperature maintained at 100° F. A current density of twenty-five (25) amperes per square foot accomplished the complete removal of the rust leaving an entirely clean surface in a period of about two (2) minutes.

#### Example III

A similar solution as that employed in Example II with the addition of one hundred (100) grams per liter of sodium cyanide was used in cleaning rusty steel. The addition of the sodium cyanide shortened the derusting time to approximately one and one-half (1.5) minutes.

#### Example IV

A solution was prepared containing sodium hydroxide, approximately one hundred (100) grams per liter, sodium cyanide, approximately seventy (70) grams per liter and as complexing agents, ethylene glycol, approximately eighteen (18) grams per liter, and glucose, approximately ten (10) grams per liter. Temperature was 130° F. Corroded rusty steel was immersed in the solution, and used as the cathode, while a carbon electrode similarly immersed served as the anode. A current density of approximately twenty-five (25) amperes per square foot accomplished the complete removal of rust, leaving a clean surface in a period of about two and one-half (2.5) minutes.

#### Example V

A solution was prepared containing sodium hydroxide, approximately two hundred forty (240) grams per liter, and mannitol as the complexing agent, approximately one hundred twenty (120) grams per liter. Temperature was 130° F. Rusty steel made the cathode in this bath with a current density the same as in Example IV resulted in complete cleaning in a period of about seven (7) minutes.

*Example VI*

A solution containing the same mixture of ingredients as employed in Example V, with the addition of sodium cyanide, about one hundred twenty (120) grams per liter accomplished complete cleaning of the metal surfaces in a period of about four (4) minutes.

*Example VII*

A solution bath was prepared containing sodium hydroxide, about two hundred forty (240) grams per liter and hydroxyethyl ethylene diamine triactic acid, one hundred twenty (120) grams per liter. Temperature was 130° F. Heavily rusted iron was made the cathode in this solution during passage of a current density of twenty-five (25) amperes per square foot. The metal was thoroughly cleaned in a period of about five (5) minutes.

*Example VIII*

Example VII was repeated with the addition of sodium cyanide, about one hundred twenty (120) grams per liter to the electrolyte which reduced the period of treatment to approximately four (4) minutes.

*Example IX*

A bath was prepared employing sodium hydroxide, two hundred forty (240) grams per liter, and ammonia triacetic acid as the complexing agent, approximately one hundred twenty (120) grams per liter. Temperature was 130° F. Using this solution, the period of time required for cleaning rusting steel under similar conditions as specified in Example VIII was approximately five (5) minutes.

*Example X*

The addition of sodium cyanide one hundred twenty (120) grams per liter reduced the treatment period in Example IX to approximately four (4) minutes.

As pointed out before, the solution of the invention can be used also as a vehicle from which certain metals can be plated out onto certain metals. Those which can be so plated out are such as cadmium, zinc, tin, copper and silver. On the other hand, by adding such a metal to the solution, cleaning, deoxidizing and plating can be done in one continuous operation when the foreign matter is electrically nonconducting, the electrolysis being continued, of course, beyond the cleaning and/or deoxidizing stage for so long as may be necessary in order to secure the desired thickness of deposit, and the current being maintained wholly unidirectional ordinarily with the work the cathode, at least from the time the cleaning and deoxidizing has been completed. When the foreign matter is electrically conducting, for example a conducting scale, and is not removed by unidirectional current with the article the cathode, a plate can be laid down on the foreign matter. The concentration of the metal to be plated out may be between say one (1) gram and fifty (50) grams per liter of the solution. The higher concentrations are rather wasteful, however, because of losses due to drag-out. Ordinarily, I use between about eight (8) grams per liter and thirty-two (32) grams per liter of the respective metal, and by preference about fifteen (15) grams per liter. Zinc can be added to the solution as zinc sulphate (first dissolved in water and this solution added to the primary solution), or as zinc oxide or zinc cyanide. Zinc can be deposited on low carbon steel, but does not plate well onto cast iron or high carbon steel. Cadmium plates out onto low carbon and high carbon steel, and cast and malleable iron. Cadmium can be added to the deoxidizing solution as cadmium sulphate, cadmium oxide or cadmium cyanide. Tin can be added as sodium stannate or sodium stannite. Copper can be added in the form of sulphate, cyanide or carbonate. It will be understood of course that the foregoing salts are mentioned as examples. To secure complete dissolution of the metal salt, or perhaps avoid rob-

bing the bath of cyanide (or rather of the radical CN), an addition of say, sodium or potassium cyanide can be made to the solution, say to the extent necessary to cause complete dissolution of the metal salt; except in the case of tin, when, say, sodium hydroxide or potassium hydroxide may be added to the solution to the extent necessary to secure complete dissolution of the desired quantity of the tin salt. Such metals can be plated from the solution under substantially the same conditions as the cleaning and deoxidizing is done, e.g., at the same current density and solution temperatures, except that in the case of copper or tin the solution temperature should be about 150° F., and in the case of other of the metals also, solution temperatures higher than those of cleaning and deoxidizing may be desirable, or perhaps necessary in some instances, especially for higher plating efficiency. However, temperatures above, say about 130° F. tend to faster decomposition of the solution, as pointed out above.

As a specific example, assume that a piece of low carbon steel carrying red rust and no electrically-conductive scale, is to be plated with zinc; Form a solution of the dry mixture of the four active cleaning and deoxidizing agents specifically described above, in water, using about three hundred sixty (360) grams of the mixture for each liter of the final solution. To this solution, add about nineteen (19) grams of zinc oxide (ZnO) for each liter of the final solution. Add also to the solution so much sodium cyanide (NaCN) as may be necessary to produce complete dissolution of the zinc oxide. Then immerse the piece in the solution, together with a carbon electrode. Apply direct current to the two, making the piece the cathode, and with the voltage such that the current density at the piece is about fifty (50) amperes per square foot, and maintain the temperature of the solution at about 125° F. The action removes the rust and scale from the piece and also any light oil and grease there may be on it, and simultaneously deposits the zinc as a plate. Continue the current flow under the same conditions until the electroplate of zinc has reached the desired thickness. Then remove the piece from the solution, and rinse it well with running water.

As metal is abstracted from the solution in plating (zinc in the foregoing example), further salt of the metal (e.g., zinc oxide) can be added to the solution from time to time to compensate for the loss and maintain the metal concentration within the desired range as successive articles are plated, or an anode of the metal being plated out can be used.

As successive articles are treated, oil may collect on the top of the solution, and foreign matter, etc. from the pieces being treated may collect or sludge in the bottom of the tank. The oil can be skimmed or otherwise taken away from time to time and also the sludge more or less cleaned out of the tank from time to time.

Occasional anodic treatment of low carbon ferrous metals in the solution of the invention not only cleans the surface of smut but produces a clean surface which facilitates the formation of a good bond in subsequent electroplating.

Also while above I have described the composition of this invention as a dry mixture of the active agents, it will be understood that the composition can be formed, exist, stored and handled as a solution of the active agents in water, either in concentrations suitable for use in the electrolysis or in more concentrated form.

In general it is to be understood that my invention is not limited to the details of composition and operation described above except as appears hereinunder in the claims, and these claims are to be understood as including equivalents of their elements specifically named as well as those elements themselves.

What I claim is:

1. The process of removing foreign matters, includ-

ing oxide of iron, from ferrous metals which consists in subjecting the metal to electrolysis in a solution formed by dissolving in water alkali hydroxide, about one hundred twenty (120) grams per liter of solution, tetra alkali salt of ethylenediaminetetraacetic acid, about forty (40) grams per liter of solution, triethanolamine, about fifty (50) grams per liter of solution, an alkali cyanide, about one hundred twenty (120) grams per liter of solution, and the metal undergoing treatment is made the cathode.

2. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an alkali gluconate in an amount of from about five grams per liter to saturation.

3. The process of removing foreign matter including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0 and containing an agent selected from the class consisting of alkali gluconate, alkali saccharate, ethylene diamine diacetic acid salts; ethylene diamine triacetic acid salts, ethylene diamine tetraacetic acid salts, hydroxy ethyl ethylene diamine triacetic acid salts, and triethanolamine, said agents having the common property of complexing iron into soluble form, and being present in an amount of from about five grams per liter to saturation.

4. The process of removing foreign matter including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 13.0 and containing an agent selected from the class consisting of alkali gluconate, alkali saccharate, ethylene diamine diacetic acid salts, ethylene diamine triacetic acid salts, ethylene diamine tetraacetic acid salts, hydroxy ethyl ethylene diamine triacetic acid salts, and triethanolamine, said agents having the common property of complexing iron into soluble form, and being present in an amount of from about five grams per liter to saturation.

5. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an alkali saccharate in an amount of from about five grams per liter to saturation.

6. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine diacetic acid salt in an amount of from about five grams per liter to saturation.

7. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine triacetic acid salt in an amount of from about five grams per liter to saturation.

8. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine tetraacetic acid salt in an amount of from about five grams per liter to saturation.

9. The process of removing foreign matter, including

oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an alkali gluconate in an amount of from about five grams per liter to saturation and an alkali cyanide.

10. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an alkali saccharate in an amount of from about five grams per liter to saturation and an alkali cyanide.

11. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine diacetic acid salt in an amount of from about five grams per liter to saturation and an alkali cyanide.

12. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine triacetic acid salt in an amount of from about five grams per liter to saturation and an alkali cyanide.

13. The process of removing foreign matter, including oxides of iron from ferrous metals which comprises subjecting the metals to electrolysis as the cathode in an alkaline aqueous solution having a pH of above 10.0, and containing an ethylene diamine tetraacetic acid salt in an amount of from about five grams per liter to saturation and an alkali cyanide.

14. The process of claim 2 wherein the pH of the solution is above 13.0.

15. The process of claim 5 wherein the pH is above 13.0.

16. The process of claim 6 wherein the pH of the solution is above 13.0.

17. The process of claim 7 wherein the pH of the solution is above 13.0.

18. The process of claim 8 wherein the pH of the solution is above 13.0.

19. In a method of electrolytically cleaning a ferrous metal object, the steps which comprise immersing said object in an aqueous solution consisting essentially of an alkali metal hydroxide and at least about 0.5 percent of triethanolamine, said solution having a pH above 10, and passing an alternating current of 60 cycles per second from said object through said solution.

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