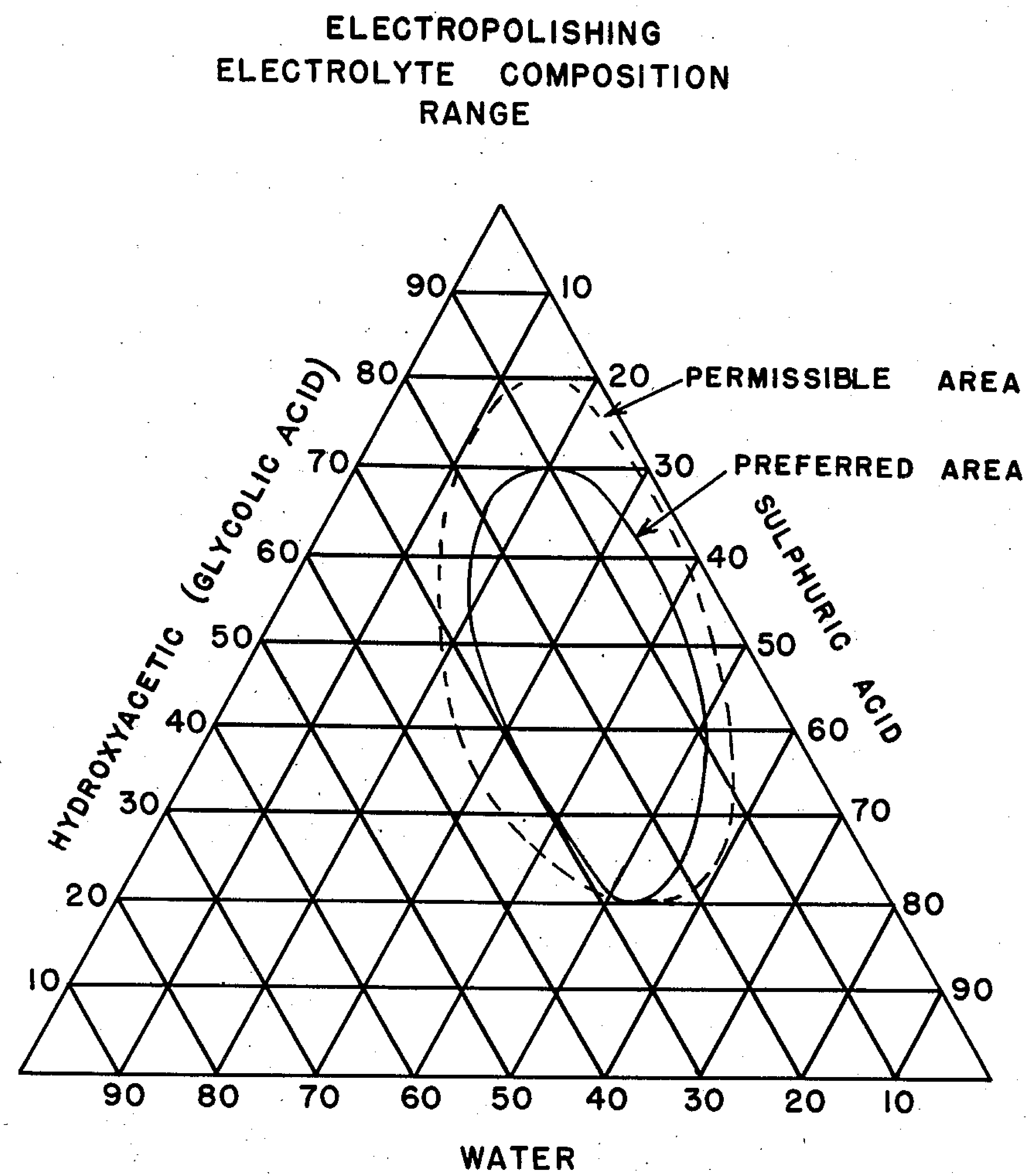
Aug. 19, 1952 J. F. KREML 2,607,722

ELECTROLYTIC POLISHING OF STAINLESS STEEL

Filed Jan. 28, 1947



PLOTTED FOR STAINLESS STEEL
ONE AMP. P.S.I., AVERAGE 90°C-
100°C. TESTS FOR 3 AND 5 MIN.

Inventor

JOHN F. KREML

By John Howard Joyce

His Attorney

Patented Aug. 19, 1952

2,607,722

UNITED STATES PATENT OFFICE

2,607,722

ELECTROLYTIC POLISHING OF STAINLESS STEEL

John F. Kreml, Baltimore, Md., assignor to Armco Steel Corporation, a corporation of Ohio

Application January 28, 1947, Serial No. 724,912

12 Claims. (Cl. 204—140.5)

This invention relates to the polishing of metal, more especially to a process and an electrolyte for electrolytically polishing the same.

An object of my invention is the provision of a simple, direct and thoroughly practical electrolytic polishing process which is highly satisfactory and reliable for the achievement of polished metal, particularly stainless steel.

Another object is that of providing a process for electrolytically polishing metal, which is readily practiced without need for extensive preparation and conditioning of the electrolye employed, as in beginning the polishing operations after shutdown and cooling of the polishing solution.

A further object of my invention is the provision of a highly effective electrolytic polishing solution which remains fluid at low temperatures as during shipment or after shutdown of metal polishing operations employing the same, and which is readily put into use and gives efficient performance under practical conditions of operation.

Other objects of my invention will in part be obvious and in part pointed out hereinafter.

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

In the single view of the accompanying drawing I graphically illustrate the composition ranges of my electrolyte.

As conductive to a clearer understanding of certain features of my invention, it may be noted at this point that stainless steel, owing to its many useful properties and an ever increasing demand for products of the metal has, heretofore, on many occasions been subjected to polishing treatment for such reasons as to provide a bright surface finish. Ordinarily, without polishing, the steel has a dull gray appearance and after polishing takes on a brightness which remains with a permanence as under conditions of corrosive attack. The steel actually varies in its corrosion-resistance and other properties according to composition and treatment, but for the sake of definition usually is recognized as containing from 0.01 to 0.25% or substantially more carbon, and about 10% to 35% or more chromium, these elements being present with or without nickel, and with or without supplemental additions of manganese, silicon, cobalt, copper, molybdenum, tungsten, vanadium, columbium, titanium, sulphur, selenium, phosphorus and the like, for special purposes, and a remainder which is substantially all iron.

In certain heretofore known polishing operations as applied to stainless steel it has been the customary practice to rely solely upon mechanical expedients for achieving a polished surface. The mechanical techniques, including those of rubbing and buffing, however, often introduce minute scratches on the metal surface and more general unevennesses which affect the surface quality of the resulting polished products. A further difficulty arises in applying the necessary amount of mechanical work for polishing where the metal to be polished has relatively inaccessible areas by reason of shape or contour. Then, too, in polishing as under these conditions it often is found that the polishing equipment suffers a great amount of wear and requires too frequent replacement for practicability.

A more recently developed practice of the surface conditioning of stainless steel involves electrolytic polishing in which the steel is made the anode of a polishing electrolyte. In general, electrolytic polishing far surpasses mechanical polishing methods from the point of view of time consumed during the actual polishing operations and results obtained. Electrolytic polishing enables the achievement of greater surface brilliance and improved beauty, there being evenness and uniformity of finish despite intricate contours or angularities which may have been encountered for polishing.

Since the advent of electrolytic polishing in the stainless steel industries, however, a number of technical difficulties still remain to reflect upon efficiency and economy of the electrochemical processes employed. A number of these difficulties are traceable back to the polishing solution and electrolyte which has a substantial effect upon the character and merits of the process. In certain of the processes, the electrolyte is open to one or more of the objections of having low electrical conductivity, poor throwing power which renders it difficult to polish deep-drawn, angular or other deep-shaped objects, a too low polishing rate as applied to stainless steel, and a low boiling point leading to excessive evaporation. Many of the solutions have an exceedingly high initial cost or are extremely expensive to maintain in view of tank losses. Still other polishing solutions are difficult to prepare and use, especially considering [illegible] shipped separately to the customer to avoid solidification at low temperatures before use. Once the ingredients are mixed in proper proportions, the resulting electrolyte has a tendency to solidify at temperatures below desired operating temperatures, thus making it problematical to shut down production line polishing treatment for any prolonged periods of time as during holidays or over week ends without suffering considerable expense for maintaining the solution at predetermined high temperatures to prevent solidification. Where the temperature of the bath is lowered a hard, glossy difficultly soluble salt of the electrolyte forms. This hard, glossy substance is crystalline and builds up in the bottom of the polishing tank and along the sides thereof. After solidification sets in, the bringing of the frozen solution back to operating conditions is a slow, tedious procedure, the time consumed perhaps causing loss of production under most urgent needs. Restoration of the electrolyte by the use of steam or other artificial expedients has been found to be troublesome and expensive. Of further significance, the restored electrolyte frequently requires adjustments for losses in strength and efficiency caused by the restoration treatment, thus making it all the more desirable to avoid the inconvenience and expenses attendant upon solidification.

An outstanding object of my invention accordingly is the provision of a process for electrolytically polishing stainless steel, employing a polishing solution and conditions of operation which are practical and conducive to the achievement of satisfactorily polished stainless steel surfaces, which process is economical in initial cost and maintenance of the electrolyte solution employed, and which is well suited for shutdown at relatively low temperatures over extended periods of time without substantial solidification of the electrolyte.

Referring now more particularly to the practice of my invention, I electrolytically treat any of a wide variety of steel articles or products, as for example sheet, strip, plate, bars, wire, or shapes having a more complex surface contour such as tubes, grilles, bowls, trim, tools and instruments, using one or more of the products as the anode in an electrolytic bath comprising as principal constituents substantial amounts of glycolic acid, sulphuric acid and water, thus achieving a polished surface on the metal. The electrolyte advantageously is an aqueous solution composed of or containing, by weight, at least about 20% up to approximately 70% glycolic acid, at least about 15% up to about 55% sulphuric acid and at least about 5% up to about 30% water, these figures being predicated upon acids in anhydrous state. The composition range employed is generally indicated by the solid line ring in the accompanying drawing.

In electrolytically polishing the stainless steel articles and products, I maintain a direct current density in the electrolyte ranging from about 0.2 to 10 or more amperes per square inch of stainless steel surface under treatment, the optimum usually being approximately 0.5 to 1.0 ampere per square inch. This I supplement by maintaining the solution at an operating temperature advantageously between about 25° C. and 100° C., and preferably between about 80° C. and 100° C. Under these conditions, I achieve polished surfaces on the stainless steels in short periods of time, say for example, in about three

to five minutes, this varying of course with circumstances such as the actual concentration of the polishing bath, the current density, the temperature utilized and the nature of the articles being polished. In general, for a particular solution, the higher operating temperatures permit the lower current densities, while the lower operating temperatures require the higher current densities. Moreover, I find that where the higher current densities are employed, say on the order of 2.0 amperes per square inch, or more, somewhat broader ranges of solution may be employed, that is, 20% to 80% glycolic acid, 10% to 60% sulphuric acid and 2% to 35% water as generally indicated by the dotted ring in the accompanying drawing.

The electrolyte afforded for my electro-chemical polishing process is conveniently shipped in suitable containers as a solution which is ready for direct use without need for admixing of the several ingredients by the consumer. Where desired, of course, the ingredients may be mixed or replenished at the point of use. The electrolyte has the highly important characteristic of resisting solidification under usual temperature conditions of transit and at temperatures considerably below ordinary room temperatures where the application of heat for the polishing process has been discontinued in favor of resuming operations at a later time. As further characteristics, the electrolyte has high electrical conductivity, good throwing power and a sufficiently high boiling point to enable high temperature use without excessive losses by evaporation.

As illustrative of the practice of my invention, I employ a suitable tank for containing the electrolyte in the stainless steel polishing operations, this container advantageously being lined with acid-resisting material, as for example, lead, ceramic or glass. The electrolyte, which I pour into the tank, preferably contains by weight about 55% glycolic acid, approximately 30% sulphuric acid, and the remainder substantially all water. This solution I find is extremely valuable for achieving an electrolytically polished surface on the steel and, moreover, is capable of resisting solidification at temperatures even lower than about (—) 2° C.

For polishing, I immerse one or more stainless steel products in the electrolyte, illustratively a low-carbon 18–8 chromium-nickel stainless steel sink strainer possessing a cold-rolled surface having an area of about twenty square inches and make the same the anode by connection with a suitable source of direct current electrical supply. Also in the tank and immersed in the electrolyte are one or more cathodes such as of lead, copper or other electrically conductive material connected with the source of electrical supply. I dispose the chromium-nickel stainless steel sink strainer between the cathodes, such as between two flat lead plate cathodes, the latter being spaced about two inches away from opposite sides of the product. The cathode area is not critical but in order to achieve most satisfactory results I usually find it best to have the cathodes of a size commensurate with the bodily extent of the stainless steel to be polished, this for obtaining a more uniform polishing action. Where stainless steel articles of irregular shape are under treatment, I often resort to the use of cathodes which conform to the general configuration of the articles to avoid undue removal of metal by the polishing action. Sometimes, I place the cathode above the anode to ensure against the formation of gas pockets which otherwise might reduce the effective current density.

Before initiating the electro-chemical action for polishing the sink strainer product, I heat up the electrolyte to a temperature of about 90° C. for increased effectiveness. The supply of heat for this purpose conveniently is afforded from a suitable heating coil immersed in the electrolyte or built into the tank wall. Then, with the electrolyte heated and maintained at the temperature just named, I effect the electrolytic polishing treatment using a current, say 20 amperes at 5 volts, which courses from the source of electrical supply to the stainless steel strainer product or anode, thence through the heated electrolyte bath to the cathode and back to the source of supply. After about 10 minutes time during which an electro-chemical removal of stainleess steel from the anode progresses, I shut off the current and subject the resulting polished strainer product to rinsing as in cold water in a suitable rinsing tank or the like. In the polished condition the strainer has a very high luster and an even degree of polish. The feature of employing a rinsing tank offers the advantage of recovery of electrolyte dragged-off from the polishing tank by the product. The rinse water often is valuable for addition to the electrolyte in replacement for water losses and drag-off and accordingly I frequently avail upon this practice.

My process further is amenable to electrochemically treating stainless steel objects such as wire which are continuously moved through the glycolic acid electrolyte. As illustrative of the continuous-polishing practice, I subject 0.045 inch diameter 18-8 chromium-nickel stainless steel wire to continuous feeding through an electrolyte containing approximately 50% glycolic acid, 33% sulphuric acid and the remainder substantially all water, the operations being in a polishing tank some 10 feet in length and at a feeding speed of about 5 feet per minute longitudinally through the tank. Six equally spaced copper anodes such as rollers illustratively provide contacts for the wire, while for example cathodes made of straight lengths of copper bus bar extend on opposite sides of the wire for the length of the tank. In way of further example I employ a current density of some 6.5 amperes per square inch of the immersed wire surface and a solution temperature of about 50° C. As the moving stainless steel wire passes from the polishing tank it is advantageous to rinse the polished surface in water as by directly and continuously feeding the metal through a rinsing tank preferably adapted for recovery of drag-off of the electrolyte.

My electrolytic polishing process is successfully practiced on articles and products in which the stainless steel is of widely varying quality whether of the straight chromium or chromium-nickel grade, and reliably gives uniformly polished surfaces even where surfaces of intricate contour are encountered. Where the metal under treatment possesses a hammered surface such as is often the case of ornamental trim, hardware, and objects of art including frames, bowls and urns, an even, lustrous polish nevertheless is obtained. Other stainless steel surfaces encountered on grilles, trays, and the like, fabricated by the welding of wire, strip and other converted forms, also are polished successfully. The polished surfaces achieved are substantially free of pits, scratches or blemishes, and the welded portions likewise are free of burns, thus resisting corrosion and maintaining their attractiveness over a long period of time. The treatment in accordance with my invention is at times useful for such purposes as electrolytically removing thicknesses of metal, in the sense of a machining operation, for achieving desired dimensions of products as well as a smooth finish.

The electrolytic polishing process which I provide, moreover, is economical and capable of being carried out under operating conditions which are easy to control, or shut down as desired, as during the expeditious mass production of polished stainless steel articles of outstanding surface quality. The equipment and materials needed in the process are readily available and in actual use call for little space for the electrolytic treatment.

Thus it will be seen that in this invention there are provided an electro-chemical process and an electrolyte for polishing stainless steels in which the various objects hereinbefore noted together with many thoroughly practical advantages are successfully achieved. It will also be seen that the process is easy to set up and maintain using a supply of electrolyte constituents which are readily shipped or stored, either separately or in mixed condition for direct use.

While my invention has been described as being particularly useful for the electro-chemical treatment of stainless steel, I also employ the same procedure in conditioning or polishing any of a wide variety of other alloys or metal, among these being aluminum, Inconel and Nichrome.

It will also be understood that while I regard glycolic acid, sulphuric acid and water as being highly critical constituents in the electrolyte employed in my process, amounts of other constituents which do not substantially impair effectiveness of the solution also may be present, if desired. For example, it is readily apparent that the beneficial results of my process will be partially retained where the glycolic acid is partially replaced by some other aliphatic carboxylic acid, for example citric acid, or even an inorganic buffer, for example phosphoric acid, as employed in prior electropolishing processes.

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 as a limitation.

I claim:

1. In the production of an electrolytically polished stainless steel product, the art which comprises, subjecting the metal to anodic treatment in an electrolytic bath essentially consisting of 20% to 80% glycolic acid, 10% to 60% sulphuric acid and 2% to 35% water, all figures being by weight and based upon anhydrous acids.

2. In the production of an electrolytically polished stainless steel product, the art which comprises, subjecting the metal to anodic treatment in an electrolytic bath essentially consisting of, by weight and predicated upon anhydrous acids, about 20% to 80% glycolic acid, about 10% to 60% sulphuric acid and the remainder substantially all water, this amounting to not over about 35%, while maintaining a temperature of the electrolytic bath ranging between about 25° C. and 150° C. and a sufficiently high current density to electrically remove metal from the surface under treatment and achieve a high polish.

3. In the production of an eelctrolytically polished stainless steel product, the art which comprises, subjecting the steel to anodic treatment in an electrolytic bath essentially consisting of, by weight and predicated upon anhydrous acids, about 20% to 80% glycolic acid, approximately 10% to 60% sulphuric acid, and about 2% to 35% water, while maintaining a current density of approximately 0.2 to 10 amperes per square inch of metal surface under treatment and a temperature of the electrolytic bath ranging between about 25° C. and 150° C.

4. In the production of an electrolytically polished stainless steel product, the art which comprises, subjecting the steel to treatment in an electrolytic bath by weight and predicated upon anhydrous acids consisting of approximately 55% glycolic acid, about 30% sulphuric acid, and the remainder substantially all water.

5. In the production of an electrolytically polished stainless steel product, the art which comprises, subjecting the metal to anodic treatment in an electrolytic bath by weight and predicated upon anhydrous acids essentially consisting of about 20% to 70% glycolic acid, about 15% to 55% sulphuric acid, and about 5% to 30% water, while maintaining a current density of approximately 0.5 to 1.0 ampere per square inch of the metal surface under treatment and a temperature of the electrolytic bath ranging between about 80° C. and 100° C.

6. In the production of an electrolytically polished stainless steel product, the art which comprises, subjecting the steel to anodic treatment in an electrolytic bath by weight and predicated upon anhydrous acids composed of approximately 55% glycolic acid, about 30% sulphuric acid and the remainder substantially all water, while maintaining a current density of approximately 0.5 to 1.0 ampere per square inch of the metal surface under treatment and a temperature of the electrolytic bath ranging between about 80° C. and 100° C.

7. In the continuous polishing of stainless steel wire, the art which comprises, continuously feeding the wire through an electrolyte essentially consisting of 20% to 80% glycolic acid, 10% to 60% sulphuric acid, and 2% to 35% water, while

maintaining anodic contact to said wire while in said electrolyte, all figures being by weight and based upon anhydrous acids.

8. An electrolyte solution of the character described, essentially consisting of as the principal constituents thereof, 20% to 80% glycolic acid, 10% to 60% sulphuric acid and remainder substantially all water up to 35%, all figures being by weight and based upon anhydrous acids.

9. An electrolyte solution of the character described, essentially consisting of, by weight and predicated upon anhydrous acids, at least about 20% but not over 80% glycolic acid, at least about 10% but not over 60% sulphuric acid, and at least about 2% but not over 35% water.

10. An electrolyte solution having non-freezing tendencies at low temperatures and essentially consisting of, by weight and predicated upon anhydrous acids, about 20% to 70% glycolic acid and about 15% to 55% sulphuric acid, and about 5% to 30% water.

11. An electrolyte solution having non-freezing tendencies at low temperatures and essentially consisting of, by weight and predicated upon anhydrous acids, about 55% glycolic acid, approximately 30% sulphuric acid, and the remainder substantially all water.

12. The method of anodically polishing stainless steel articles which comprises electrolyzing the article as anode in an electrolyte of approximately the following composition:

Aqueous sulfuric acid (95% by wt.)	8 to 43% by volume
Aqueous glycollic acid (70% by wt.)	The balance

to achieve a mirror-like polish on the article.

JOHN F. KREML.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,335,354	Ostrofsky	Nov. 30, 1943
2,382,865	Dittmar	Aug. 14, 1945

OTHER REFERENCES

"Hackh's Chemical Dictionary," 2nd edition (1937), page 526.