

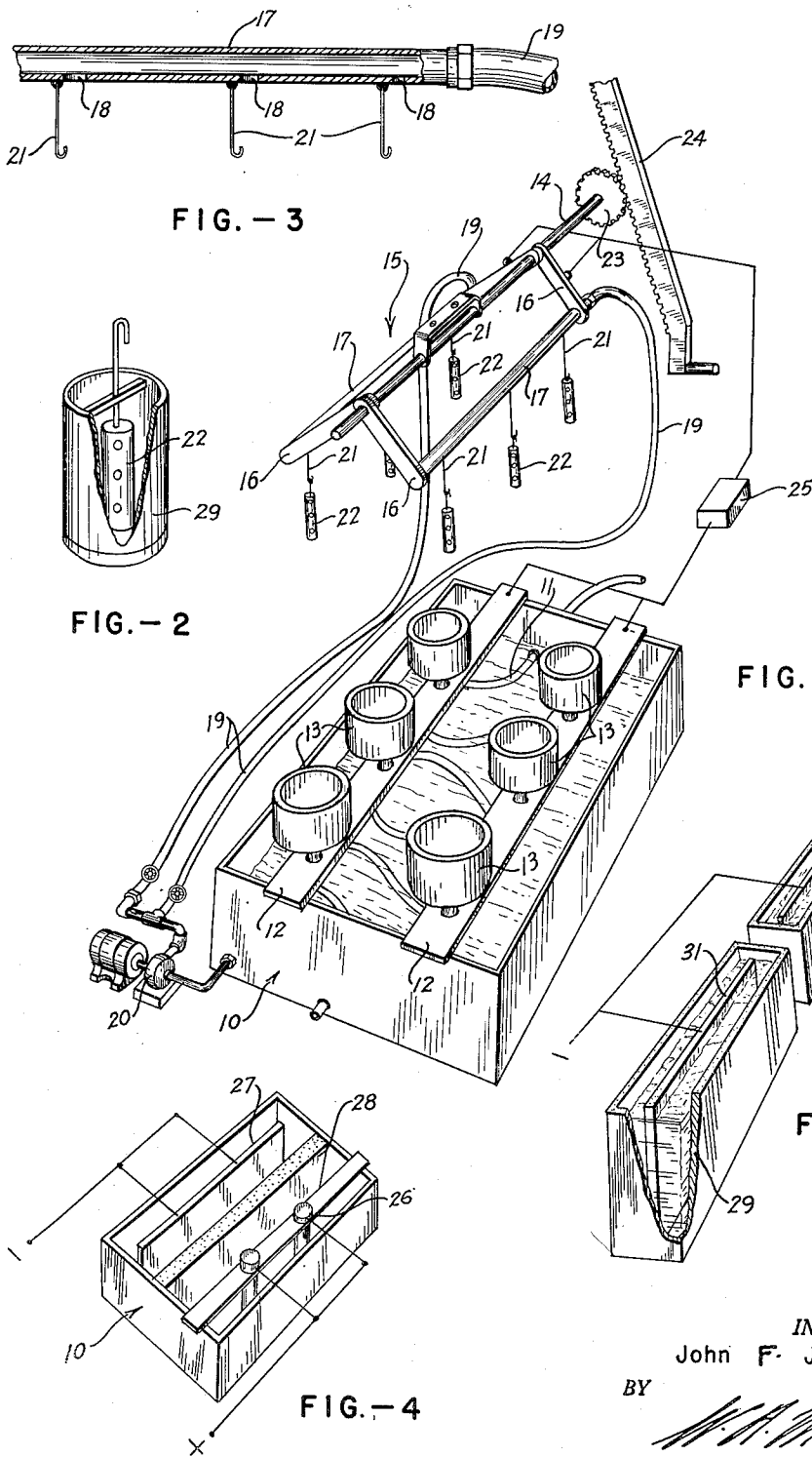
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APPARATUS FOR ELECTROPOLISHING METALS

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APPARATUS FOR ELECTROPOLISHING METALS

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My invention is directed to electro-polishing, particularly with respect to an apparatus for electrically polishing selected surfaces of objects formed of stainless steel and the like.

Electro-polishing, or the anodic polishing of metal has been known for some time, and considerable development work has been directed towards the attainment of a single satisfactory method for all metals over the past few years. This work has, however, been in general unsuccessful, particularly with respect to the development of an electro-polishing solution or bath which can be used for polishing the various metals and metal alloys most frequently encountered in commerce. The art, as it is known today, discloses various special baths of widely varying character, which may be used in the electro-polishing of specific commercial metals or metal alloys, but which are ineffective if an attempt is made to polish metals belonging to a class other than that for which the bath is particularly adapted. As a result, the composition of an electro-polishing bath must be changed whenever the metal composition is varied.

One of the metals which presents considerable difficulty in electro-polishing is commercially known as stainless steel, the term being broadly applied to include metals containing sufficient chromium to render them highly resistant to corrosion. The baths which have been proposed for polishing stainless steel are each subject to objection as being in various instances highly toxic, explosive, or of short life. In some instances these prior art baths also require the maintenance of operating conditions such as temperatures, current density, or voltage, which are difficult or expensive to maintain.

The mechanical apparatus conventionally employed in electro-polishing is also subject to criticism in that it fails to realize to the maximum extent the great economy which is potentially obtainable by utilization of the electro-polishing process. For example, considerable time is required to rack and unrack the various objects to be electro-polished, and frequently during this process the bath is not in operation. If only one of several surfaces of an object is to be polished, conventional practice requires the application of a resist or similar coating to preserve a portion of the surface from reaction during the process. Application of a resist is ordinarily a time-consuming process, and in addition it has been found that the conventional resist compositions are not in all instances satisfactory for use in electro-polishing bath compositions.

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A primary object of my invention is to at least in part overcome these and other defects in prior art proposals through the provision of a non-toxic, non-explosive electro-polishing bath characterized by its adaptability to electro-polishing of several different classes of commercial metals with only minor modification, my bath being particularly adaptable to the electro-polishing of ferrous alloys containing substantial quantities of chromium.

Another object of my invention is to provide apparatus particularly suited for use in conjunction with my bath, which not only reduces the amount of labor required, but which also extends the life of the bath.

Other important objects include the provision of apparatus for selectively polishing the internal surfaces of metal containers without altering the condition of the finish of the external surface, and which provides rapid, safe, and automatic means for interrupting the circuit as completed work is removed and new work is presented to my apparatus for polishing.

Other important objects of my invention, as well as its several advantages will be disclosed in the following detailed description, and in the appended drawings, in which:

Fig. 1 is a schematic view of apparatus utilized in my invention;

Fig. 2 is a partially broken away perspective of a form of cathode;

Fig. 3 is a partially broken away elevation of the cathode support of Fig. 1;

Fig. 4 is a schematic perspective view of a tank and electrode arrangement; and

Fig. 5 is a partially broken away perspective view of a cathode device.

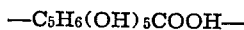
The two general classes of metals to which my bath is particularly adapted are aluminum and stainless steel. As previously indicated, by stainless steel I mean that group of ferrous alloys which contain sufficient chromium to be highly resistant to corrosion. These alloys divide themselves logically into sub-classes, the first of which includes stainless steels having a martensitic or ferritic structure, and which contain only minor quantities of nickel, the alloy balance being selected to produce a non-austenitic structure. The second group consists principally of the conventional forms of stainless steel commonly known as 18-8, and which ordinarily contain sufficient nickel to produce an austenitic structure. Both aluminum and its common alloys and the first of the stainless steel sub-groups, namely the non-austenitic, may be satisfactorily

electro-polished by subjecting them to the action of a direct electric current flowing through a bath having the following basic composition:

Bath composition (per cent by volume)

	Minimum	Optimum	Maximum
	Percent	Percent	Percent
Polyethylene Glycol (200-400 molecular weight).....	1.0	5.0	20.0
Phosphoric Acid (75%).....	75.0	93.0	98.9
Gluconic Acid.....	0.1	2.0	5.0

With reference to the various components of my bath as indicated above, the polyethylene glycol should have a molecular weight of from 200 to 400, since I have found that ethylene glycols having molecular weights departing substantially from the indicated range produce less satisfactory results, and will in some instances form objectionable compounds while the bath is in operation. The phosphoric acid employed in compounding my bath may be of the commercial type containing about 75% phosphoric acid, the balance being water and small quantities of impurities which are not in general of a harmful nature. If phosphoric acid of a higher degree of purity is employed, sufficient water should be added to approximate the strength indicated, since water in small quantities is necessary to the proper operation of my bath. Gluconic acid



is preferably formed by adding to the bath quantities of delta glucono-lactone, which hydrolyzes with the water to form the desired gluconic acid. This bath when utilized for the electro-polishing of aluminum or aluminum alloys should be maintained at a temperature of between 100°-180° F., the optimum temperature being in the neighborhood of 120°.

The work is brought into contact with the bath and connected as the anode with a suitable source of direct current, the other terminal of the circuit being connected to a cathode of suitable composition such as lead, which is immersed in the bath. The current density should be regulated to yield from 75 to 750 amperes per square foot at from 5 to 12 volts, the optimum voltage being in the neighborhood of 8 volts. Increasing the temperature of my bath under the above-defined conditions above the 125° optimum range tends to increase the speed with which the aluminum or stainless steel article will be polished, but I have found such a temperature increase to ordinarily be undesirable, since the tendency towards etching the surface increases with the increase in temperature, and as a result will often produce unsatisfactory work.

The same bath composition may be utilized for polishing stainless steels falling in the first subgroup, but the conditions under which the polishing proceeds should be altered to correct for the characteristics of the metal. For example, the temperature of the bath should be maintained between 175° F. and 235° F., approximately 200° F. being the optimum temperature. Voltage should also be increased to between 9 and 11 volts, and the current density established at a high level, on the order of 700 amperes per square foot where possible.

After my bath, having the above defined composition, has been operated for a short period, it will be found that even when operated at a relatively high temperature objectionable or toxic fumes will not be generated, and in general fume-

disposal equipment is unnecessary, although there will, of course, be a certain amount of gas generated at both the anode and cathode. A sludge consisting principally of insoluble phosphates will also gradually deposit in the bottom of the bath container, and should be periodically removed. The concentration of phosphoric acid should be maintained by the addition of either phosphoric acid or phosphoric anhydride, the latter being selected when the quantity of water in the bath increases beyond the desired limits, or when it is desired to increase the phosphoric acid content without increasing the volume. Further maintenance is unnecessary unless by careless operation deleterious elements are introduced. The evolution of gases from the anode and cathode provides all of the agitation necessary in the bath, thus eliminating the need for mechanical devices, which are ordinarily employed to insure uniform composition.

The bath hereinbefore described may be simply converted into a bath which is highly efficient in electro-polishing austenitic stainless steel, conventionally known as 18-8, and usually containing approximately 18% chromium and 8% nickel, by adding to the bath from 5% to 50%, and preferably 20% by volume, concentrated sulfuric acid. My basic bath will polish austenitic stainless steel even in the absence of sulfuric acid, but the addition of the acid greatly increases the efficiency of the bath, and improves the character of the surface produced. After the acid has been added, the austenitic stainless steel can be electro-polished at the temperatures, current densities, and voltages hereinbefore defined for use in electro-polishing aluminum. In general, this modified form of my bath exhibits the same characteristics as the basic bath composition except that the sludge forming in the bottom of the bath container will consist principally of insoluble phosphates and sulphates, and will require the addition of quantities of sulfuric acid and phosphoric acid from time to time in order to maintain the composition of the bath at the desired concentration. Glycolic may also be added to either of the above-indicated bath compositions in quantities up to 10% by volume, but this addition is as a rule unnecessary and is employed only when unusual difficulty is encountered in obtaining a satisfactory finish.

When in use, I prefer to place my bath solution in an open topped container 10 of a suitable acid-proof construction, preferably provided with a coil 11 disposed at or near the bottom of the container 10 through which a hot or cold liquid can be circulated to control the temperature of my bath. Ordinarily, temperature control is obtained by controlling the quantity of cold water circulated through the coil 11, since the temperatures required for the operation of my bath are not high, and the heating of the bath produced by the passage of electric current between the anode and the cathode is ordinarily sufficient to maintain the bath at the desired temperature. Although particularly useful in electropolishing stainless steel, my invention is also applicable to certain of the brasses without modification. The brasses which may be successfully processed are alloys consisting principally of copper and zinc, but in which silicon is substantially absent and in which the total lead or tin content is less than about 7%. Other alloying elements may be present in small amounts without adversely affecting the resulting polish.

I have illustrated in Fig. 1 apparatus particu-

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larly adapted for polishing the interior of hollow metal objects 13 without altering the finish of the outside of these objects. Suitable metal supports 12, ordinarily two in number, are placed lengthwise over the container 10 near the opposite edges and are shaped to receive and support the hollow work pieces 13 in such position that solution flowing over the lips of the containers will drain into the container 10. A support 15 is mounted centrally over the tank, as from a building roof, and rotatably supports an elongated metal rod 14, which is in turn rigidly connected to spaced yokes 16 extending outwardly and downwardly from the ends of the rod 14. The ends of the yokes are connected by spaced parallel metal pipes 17 of copper or the like, each provided with a plurality of spaced hooks 21 or the supports from which cathodes 22 of lead, copper, or the like may be suspended. The apparatus may be lowered to suspend the cathodes 22 within the work, the other side, with its depending cathodes, being elevated and inoperative. During at least one portion of the arc of movement, normally when the parallel pipes 17 are level, the cathodes 22 on both of the pipes 17 will be suspended above containers 13, thus preventing the flow of current between the cathodes and the work. To conveniently actuate my cathode suspension device, I may secure a gear 23 to an end of the rotatably supported member 14 for engagement with a rack 24 suitably mounted in guides, and arranged for access by an operator from floor level.

Each of the pipes 17 is provided with a graduated series of openings 18 formed in the pipe 17 near the hooks 21 for discharging solution drawn from the container 10 downwardly through the openings 18 into the work 13. Circulation is obtained by operation of a pump 20 having an inlet communicating with the container 10 somewhat above the container bottom and discharging into flexible conduits 19, which convey the solution to the pipes 17. The diameters of the openings 18 are adjusted, increasing with the distance of the opening from the inlet end of the pipe 17 in such manner that each of the work pieces 13 receives approximately the same quantity of solution from its corresponding opening, the excess overflowing the work 13 and returning to the container 10. A suitable source of direct current, such as a rectifier 25, is connected to the yokes 16 and to the conductive support members 12 in such manner that the work 13 becomes the anode of the circuit. The circuit is completed by the passage of a current through the solution between the cathodes 22 and the corresponding work pieces 13.

In operation, the work 13 is placed upon one of the supports 12 and the rack 24 moved to bring the corresponding cathodes 22, suspended from the bar 17, downwardly into the hollow work 13. The pump 20 is started, and the discharge controlled by suitable valves (not shown) to pass the output of the pump through only the lower of the pipes 17. When the containers 13 are filled, current flows between the work and the cathodes 22, the solution discharged into the work 13 from the openings 18 in the pipe 17 overflowing the work and returning by gravity to the container 10. Under these conditions only the interior of the work 13 will be electropolished, the condition of the external surface remaining substantially unchanged throughout this treatment. While the work on one of the supports is being electropolished, the operator places work in the other support; and as the operation on the first set of

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work pieces 13 is completed operates the rack 14 to rock the cathode suspension device. This raises one of the pipes 17 and lowers the pipe on the opposite side, the current through the rectifier 25 being interrupted as the pipes 17 approach a common level; and being recompleted as the cathodes 22 enter the unpolished work 13. The operator then removes the polished work and replaces it with unpolished work, the operation being continued until all of the work has been completed.

In the course of operation, various insoluble phosphates and/or sulphates will be formed, which precipitate from the bath, and which may be periodically removed. These compounds are not particularly harmful; however, under ordinary operating conditions the chromium removed from the work, apparently in trivalent form, constitutes a detrimental material, which adversely affects the brightness of the wash. The presence of chromium ions in the bath is harmful only when these ions are present in other than their hexavalent condition. It is therefore highly desirable to convert all chromium ions in the bath to the hexavalent condition and to maintain them in such state. This may be attained by the use of an apparatus such as that illustrated in Fig. 4, wherein a porous partition 28 of dielectric material is interposed between the anode 26 and the cathode 27. The purpose of this partition is to confine the hydrogen gas formed at the negative pole or cathode to the area immediately around the cathode and to discharge the gas as quickly as possible from the bath. Thus, the oxygen generated at the anode or positive pole is allowed to bubble slowly through the bath, saturating it to the greatest extent possible and driving the oxygen into contact with the maximum number of chromium ions.

The oxygen being an oxidizing gas tends to convert all of the chromium ions to the hexavalent condition. Obviously, since the gases will tend to rise around the cathode, it is not necessary that the partition 28 extend downwardly below the cathode, but simply that it serve to define, at least in part, an upright conduit through which the gas can escape with a minimum of contact with the solution. The interposition of the porous partition between the anode and cathode does not adversely affect the flow of current between the electrodes, and should in its preferred form extend upwardly above the surface of the bath in the container. Porous earthenware or ceramic material has been found to be highly satisfactory as a partition material, but other material of a porous dielectric nature may be substituted for the ceramic if desired. For example, mats of glass wool may be employed or a coarse cloth having the general texture of heavy canvas may be employed, provided it is formed of thread made from an acid resistant material, such as for example the various vinyl polymers. The composition of the cathode 27 is not of major importance, but may be formed of lead, copper, or similar materials.

It is not to be understood that it is necessary to utilize a partition 28, since individual cathodes 31 (Fig. 5) may be immersed in containers 29 of porous material, which are in turn supported in the bath container 10 with the lips of the containers 29 above the level of the bath. Furthermore, the shape of the porous containers 29 is not of particular importance, and may be of cylindrical shape, as indicated in Fig. 2, for use in conjunction with a cylindrical cathode 22, as illustrated in Fig. 1. The containers 29 or the

partition 28 should, however, be spaced from the cathode and open at the top to permit the ready escape of gas.

From the foregoing it may be seen that I have provided a bath solution which in its simplest form may be employed in electropolishing aluminum, aluminum alloys, non-austenitic stainless steel, and to a limited degree, austenitic stainless steel surfaces, and by the addition of sulfuric acid the same bath solution is made particularly adaptable for electropolishing austenitic stainless steels. When used in conjunction with the apparatus herein illustrated, this bath exhibits a long and highly satisfactory life, since the chromium ions formed in the bath during the electropolishing operation are maintained in a hexavalent condition. The apparatus described permits the polishing of internal surfaces at a rapid rate without affecting the external surface of the work; and at the same time provides safe, effective, and automatic means for interrupting the current between the anode and cathode while the operation is being shifted from one set of work pieces to another. When the prescribed operating conditions are maintained, it will be found that my bath is effective in breaking through the surface film which forms on metal objects, particularly those of aluminum or stainless steel, and forming a high specular luster on the work. Particular importance is attached to the use of a porous, acid resistant member around the cathode, since it has been found that utilization of such a device not only substantially increases the life of the bath, but also improves the character of the finish produced.

The foregoing detailed description has been made in compliance with Title 35, United States Code, Section 112, but is to be understood as being descriptive in nature, rather than by way of limitation. I do not, therefore, wish to confine myself to the precise details hereinbefore disclosed, except as defined in the appended claims.

I claim:

1. Apparatus for electro-polishing the interiors of metal containers comprising a reservoir, a pair of spaced parallel conductive means extending

over the reservoir between the edges thereof, each adapted to support a row of containers to be polished, a support above the reservoir, spaced yokes journaled on the support on an axis parallel to said conductive means, spaced metal pipes parallel to said conductive means extending between said yokes and each provided with a plurality of openings, each opening being above one of the containers, metal electrodes depending from the pipes for immersion in the containers, said yokes and pipes being disposed and arranged for rocking movement on said support for first raising the electrodes on one of the pipes above one of said rows of containers and then lowering the electrodes on the other pipe into the other row of containers, means for forcing electrolyte from the openings in one of the pipes into the corresponding row of containers, and means for passing a direct current between the electrodes and said containers.

2. The combination claimed in claim 1, including a pump having its intake side communicating with the reservoir and valved connections between the discharge side of the pump and said pipes, whereby electrolyte may be supplied selectively to said rows of containers.

3. The combination claimed in claim 1, in which the openings in the pipes are graduated in size with the largest openings most remote from the means for forcing electrolyte, whereby electrolyte is supplied to all the containers in a row at substantially the same rate.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,344,859	Fox	Mar. 21, 1944
2,411,410	Beckwith	Nov. 19, 1946
2,447,270	Olsen	Aug. 17, 1948
2,475,586	Bartlett	July 12, 1949

FOREIGN PATENTS

Number	Country	Date
207,209	Switzerland	Dec. 16, 1939