This invention relates to polishing compositions for metals and more particularly to a process for electropolishing metals with such compositions. The invention is especially concerned with the preparation of compositions for electropolishing stainless steel surfaces. The invention is also applicable to polishing carbon steels, aluminum, brass and other metals.

It is well known to polish the surface of metal articles by a process known as electropolishing in which the metal article is immersed in a chemical solution and an electric current is passed therethrough with the article as the anode. Some metals, such as aluminum, can be polished satisfactorily in chemical solutions without applying an electric current. Stainless steels and carbon steels present special problems.

Generally speaking, chemical solutions which are satisfactory for polishing one type of metal are not suitable for polishing other types of metals. Thus, it is standard practice to use one type of electropolishing bath for stainless steel and another type of electropolishing bath for carbon steel.

One of the difficulties normally encountered in the electropolishing of metals, such as stainless steel, is the tendency toward pitting. This tendency exists, for example, when a phosphoric acid solution is used as the chemical bath for the electropolishing of stainless steel. A phosphoric acid weight oxyalkylene compound in an amount corresponding to 0.02% to 2.0% by weight of the total H₃PO₄. The water may be present in the composition in amounts up to 50% by volume. Especially good results have been obtained with a polishing bath in which the concentration of phosphoric acid, as H₃PO₄, is 75% to 85% by weight of the total H₃PO₄ and water.

The temperature used in carrying out the polishing process can be varied over a relatively wide range, depending upon the type of metal to be polished. In general, the temperature may vary from room temperature of around 70° to temperatures exceeding 250° F.

The direct current voltage applied to the metal to be polished can also vary, depending upon the particular metal and the conditions used in the polishing operation. Stainless steels of the 200 and 300 series are preferably polished in a bath of the type previously described at temperatures of 150° F. to 160° F. for 5 to 10 minutes, using an applied direct current voltage within the range of 3 to 15 volts, preferably around 8 to 10 volts. Stainless steels of the 400 series are preferably electropolished in accordance with the invention at a temperature of about 175° F. for a period of about 5 minutes using an applied direct current voltage of 5 to 6 volts. Carbon steels, such as SAE 1010 steel are preferably electropolished in accordance with the invention at a temperature of 140° F. to 160° F. for a period of 5 to 10 minutes using an applied direct current voltage of 3 to 7 volts. Brass is preferably electropolished in accordance with the invention at temperatures of 70° F. to 120° F. for 1 to 5 minutes using an applied direct current voltage of 1 to 2 volts and sometimes up to 15 volts. Copper is preferably polished under the same conditions as brass. While temperatures higher than 120° F. can be used in polishing copper and brass the action on the metals is apt to be too fast with too much levelling and undesirable gassing. Aluminum and alloys of aluminum, such as 3-S aluminum and 17-ST aluminum can be polished in a bath of the type herein described without an applied electromotive force but better levelling action is obtained by polishing the aluminum in a bath of the type herein described at a temperature of 100° F. to 160° F. for 1 to 5 minutes using an electric current of 1 to 10 volts.

The period to which the metal article is subjected to electropolishing in accordance with the invention is subject to variation, depending upon the amount of levelling action desired. In some cases a period of time as short as 30 seconds may be sufficient to obtain some brightness and a longer time is required to obtain the desired amount of levelling action. Deburring can also be accomplished by using longer periods of time.

While the voltage used is not normally critical, if the voltage is too low in the electropolishing of stainless steel, the steel may be etched. Likewise, in the electropolishing cold rolled SAE steel, such as 1010 and SAE 2330, if the voltage is too low etching may occur and again if the voltage is too high etching may occur.

The quantity of the oxyalkylene compound used must be relatively small because too great a quantity causes polarization and this can be determined visually by the appearance of a white film on the metal which is being electropolished. Too great a quantity also tends to cause foaming which is undesirable. The best results have been obtained by using oxyalkylene compounds having a molecular weight within the range of 400 to about 2000 and especially good results have been obtained with polyoxypropylene glycols having a molecular weight of about 750 and polyoxyethylene glycol having a molecular weight of about 600. Polyoxyethylene glycols having molecular weights of 200, 300, and 400, respectively, have been used in the practice of the invention but in general are less effective. The so-called carbowax materials which are solid polyoxyethylene glycols having molecular weights of 6000 to 10,000 separate and float on the bath and hence they are undesirable. The methoxy polyoxyethylene glycol having a molecular weight of 750 has been incorporated in the bath and is effective but also has a tendency to come out of the bath and float on the surface. For most purposes, therefore, it is desirable to use a polyoxyalkylene glycol consisting essentially of oxyethylene.
groups or oxy-1,2-propylene groups, or both oxyethylene and oxy-1,2-propylene groups in such proportions that the molecular weight is within the range of 600 to 2000.

Where the oxyalkylene compound consists essentially of both oxyethylene and oxy-1,2-propylene groups, the molecular weight can be as high as 6000 because these materials, unlike the solid high molecular weight polyoxyethylene glycols, are normally liquid. The oxyalkylene compound should be one which remains dissolved in the phosphoric acid solution in sufficient amounts to enhance the brightening action under the conditions used in the metal polishing process.

While the invention has been described particularly with reference to the high molecular weight polyoxyalkylene glycols, it will be understood that the aliphatic ethers of these glycols may be used in which case one or both of the terminal hydroxyl groups of the glycol is replaced by an alkoxy group, such as methoxy, ethoxy, propoxy, butoxy, and homologues thereof.

The current density used in the various electropolishing operations is subject to variation but is preferably within the range of 10 to 150 amperes per square foot. The general range of voltage used is normally preferably at least 2 volts and not more than 20 volts.

The tank in which the electropolishing operation is carried out preferably consists of chemical rubber-lined carbon steel, lead-lined carbon steel, carbon brick or acid brick.

After an article has been subjected to polishing it should be rinsed with water and the rinse tank is preferably constructed of stainless steel, chemical rubber-lined carbon steel, lead-lined carbon steel, ceramic, stoneware, plastic, or wood.

Heating can be accomplished with steam which is passed through coils constructed of a suitable acid resistant material. Immersion heaters can also be used. Electrical current can be supplied by a D.C. motor, generator, or rectifier.

Cathodes of chemical lead are preferred. However, copper or carbon cathodes may be used. Anode rod or solution agitation is desirable to give uniformity of polishing action.

The phosphoric acid solution containing the oxyalkylene compound is preferably first prepared as a concentrate which contains four to five times as much of the oxyalkylene compound as would be present in the final polishing bath. This concentrate is then diluted by using 1 part of the concentrate with 4 or 5 parts of orthophosphoric acid of the desired concentration.

The best mode contemplated for the practice of the invention is illustrated by the following examples in which the quantities are stated in parts by weight unless otherwise indicated.

**Example I**

A concentrate is prepared by adding 15 cc. of a polyoxypropylene glycol having a molecular weight of about 750 (P-750 polypropylene glycol) to a gallon of phosphoric acid containing 85% by weight of H₃PO₄ in water.

One part of the foregoing concentrate is diluted with 4 parts of 75% by weight orthophosphoric acid to produce a polishing bath which is placed in a suitable container. Stainless steel (e.g., Stainless 416) is then immersed in this bath and a direct current of 6 to 8 volts is passed through the bath using the stainless steel as the anode and a lead cathode at a temperature of 175° F. for a period of about 5 to 10 minutes until the desired amount of polishing and levelling has been obtained.

In a similar manner the same bath can be used for other stainless steels of the 400 series.

**Example II**

The procedure is the same as that described in Example I except that instead of stainless steel of the 400 series, stainless steels of the 200 and 300 series are used and the temperature is within the range of 150° F. to 160° F. for 5 to 10 minutes with a direct current voltage of around 8 to 9 volts.

**Example III**

The procedure is the same as in Example I except that the metal article to be polished is brass. The polishing operation is carried out at a temperature of 100° F. to 120° F. from 1 to 5 minutes and the direct current voltage is 1 to 2 volts.

**Example IV**

The procedure is the same as in Example I except that the article to be polished is made of carbon steel SAE 1020. The process is carried out for 5 to 10 minutes at 140° F. to 160° F. and the direct current voltage is 3 to 6 volts.

**Example V**

The procedure is the same as in Example I except that the article to be polished is made of an alloy steel SAE 2320. The process is carried out from 5 to 10 minutes and the temperature is 140° F. to 160° F. with a direct current voltage of 3 to 6 volts.

**Example VI**

The procedure is the same as that described in Example III except that copper is substituted for brass.

**Example VII**

The procedure is the same as that described in Example I except that an aluminum alloy, 17-5T, is used. The process is carried out for 1 to 5 minutes at a temperature of 100° F. to 160° F. and a direct current voltage of 1 to 10 volts is employed.

**Example VIII**

The procedure is the same as in Example VII except that 3-S aluminum is substituted for the 17-5T aluminum alloy.

It will be understood in all of the foregoing examples that the metal article which has been polished is rinsed with water or a suitable rinse solution immediately after the polishing operation.

The concentrate employed for the purpose of the invention is extremely stable and the baths produced therefrom are capable of producing smooth, bright surfaces on many different types of metal articles. The invention is especially suitable for polishing stainless steels because of the difficulty of polishing such steels by other methods. The action of the bath removes all embedded foreign metals from the surface of the stainless steel and leaves a passive film thereby increasing the corrosion resistance of the stainless steel. Deburring is simultaneously accomplished by the polishing operation. The polishing baths require no maintenance other than replacement necessitated by dragout. Dragout losses can be replenished by additions of one part of the concentrate as described in Example I to two parts of 75% by weight of orthophosphoric acid at intervals. Sludge which is formed should be removed periodically from the bottom of the tank.

The invention is especially advantageous in making it possible to eliminate the pitting action which normally attends the use of phosphoric acid in a bath of this type. The articles which have been polished in baths provided in accordance with the invention also have the advantage that they are readily rinsed. A most important advantage of the invention from the commercial standpoint is the versatility of the bath which makes it possible to use it for polishing different types of metals.

The invention is hereby claimed as follows:

1. A polishing composition consisting esssentially of an aqueous solution of phosphoric acid, as substantially the sole acid, containing up to 50% by volume of water and 0.02% to 2.0% by weight of the H₃PO₄ of an oxyalkylene compound having a molecular weight of at
least 200, said oxyalkylene compound being soluble in the bath in the proportions used and under the conditions of polishing, said oxyalkylene compound being from the class of compounds consisting of normally liquid polyoxyalkylene glycols and aliphatic ethers of such glycols in which the oxyalkylene groups are from the class consisting of oxyethylene groups, oxy-1,2-propylene groups and both oxyethylene groups and oxy-1,2-propylene groups in the same molecule.

4. A metal polishing composition consisting essentially of a solution of orthophosphoric acid, as substantially the sole acid, containing about 75% to 85% by weight of H$_2$PO$_4$ in water and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of an oxyalkylene compound having a molecular weight of at least 200 and which is soluble in the phosphoric acid solution in the concentrations used at temperatures within the range of 70° F. to 250° F., said oxyalkylene compound being from the class of compounds consisting of normally liquid polyoxyalkylene glycols and aliphatic ethers of such glycols in which the oxyalkylene groups are from the class consisting of oxyethylene groups, oxy-1,2-propylene groups and both oxyethylene groups and oxy-1,2-propylene groups in the same molecule.

5. A metal polishing composition consisting essentially of an aqueous solution of phosphoric acid, as substantially the sole acid, containing about 75% to 85% by weight of H$_2$PO$_4$ and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of a polyoxypropylene glycol having a molecular weight of about 750.

6. A metal polishing composition consisting essentially of an aqueous solution of phosphoric acid, as substantially the sole acid, containing about 75% to 85% by weight of H$_2$PO$_4$ and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of a polyoxyethylene glycol having a molecular weight of about 600.

7. A process of chemically polishing a metal surface susceptible to polishing in a phosphoric acid bath which comprises applying a direct current voltage within the range of 2 to 20 volts at a current density within the range of 10 to 150 amperes per square foot to said metal surface as the anode in a bath consisting essentially of an aqueous solution of phosphoric acid, as substantially the sole acid, containing about 75% to 85% by weight of H$_2$PO$_4$ and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of a polyoxyethylene glycol having a molecular weight of about 750.

8. A process of chemically polishing a metal surface susceptible to polishing in a phosphoric acid bath which comprises applying a direct current voltage within the range of 2 to 20 volts at a current density within the range of 10 to 150 amperes per square foot to said metal surface as the anode in a bath consisting essentially of an aqueous solution of phosphoric acid, as substantially the sole acid, containing about 75% to 85% by weight of H$_2$PO$_4$ and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of a polyoxypropylene glycol having a molecular weight of about 600.

9. A process of polishing a stainless steel surface which comprises passing a direct current of 3 to 15 amperes per square foot through said surface while it is immersed in a bath consisting essentially of 75% to 85% by weight of H$_2$PO$_4$ as substantially the sole acid, in water and 0.02% to 2.0% by weight of the H$_2$PO$_4$ of a polyoxyalkylene glycol having a molecular weight of about 600 at a temperature of about 175° F., said glycol being from the class consisting of polyoxyethylene glycols, polyoxy-1,2-propylene glycols and polyoxyalkylene glycols in which the oxyalkylene groups are both oxyethylene and oxy-1,2-propylene groups.

10. A process as claimed in claim 9 in which a stainless steel of the 400 series is polished at a temperature of about 175° F.

11. A process as claimed in claim 5 in which the metal to be polished is a carbon steel, the temperature used is 140° F. to 160° F. and the direct current voltage is around 3 to 6 volts.

12. A process as claimed in claim 5 in which the metal to be polished is aluminum, the temperature of the bath is 100° F. to 160° F. and the direct current voltage is 1 to 10 volts.

13. A process as claimed in claim 5 in which the metal to be polished is brass, the temperature of the bath is 100° F. to 120° F. and the direct current voltage is 1 to 2 volts.

14. A process as claimed in claim 5 in which the metal to be polished is copper, the temperature of the bath is 100° F. to 120° F. and the direct current voltage is 1 to 2 volts.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,935,455

May 3, 1960

Frank J. Swagler

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 30, for "aye" read -- type --; line 46, strike out "the", second occurrence; column 5, line 1, for "oxylakylene" read -- oxyalkylene --.

Signed and sealed this 11th day of October 1960.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents