Jan. 30, 1951 J. MAZIA 2,539,455

ELECTROLYTIC POLISHING OF METALS

Filed Jan. 27, 1944 2 Sheets-Sheet 1

Fig. 1.

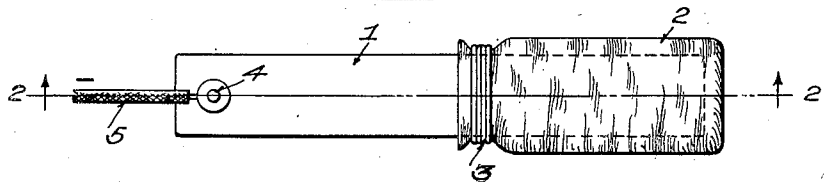


Fig. 2.

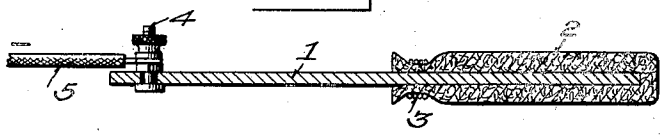


Fig. 3.

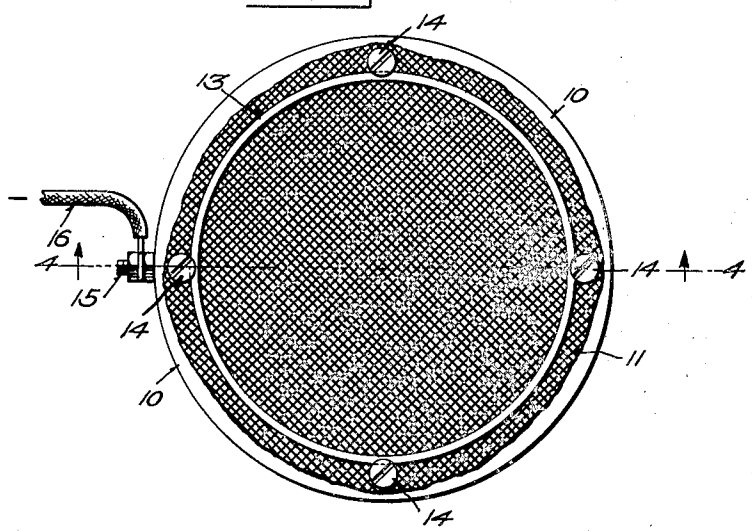
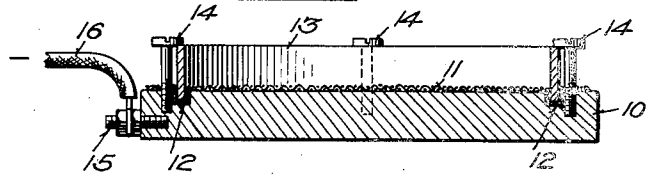


Fig. 4.



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Jan. 30, 1951 J. MAZIA 2,539,455

ELECTROLYTIC POLISHING OF METALS

Filed Jan. 27, 1944 2 Sheets-Sheet 2

Fig. 5.

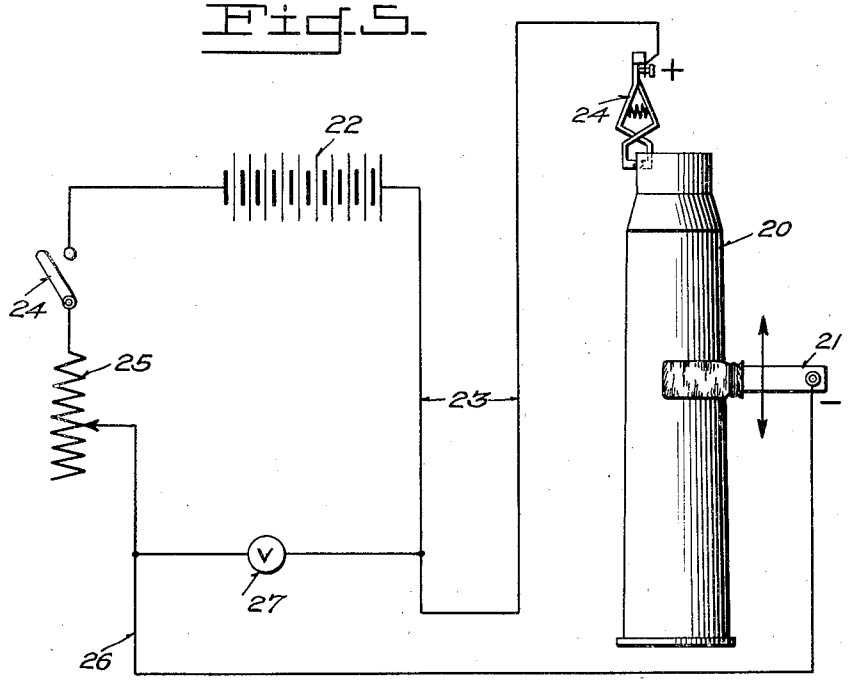
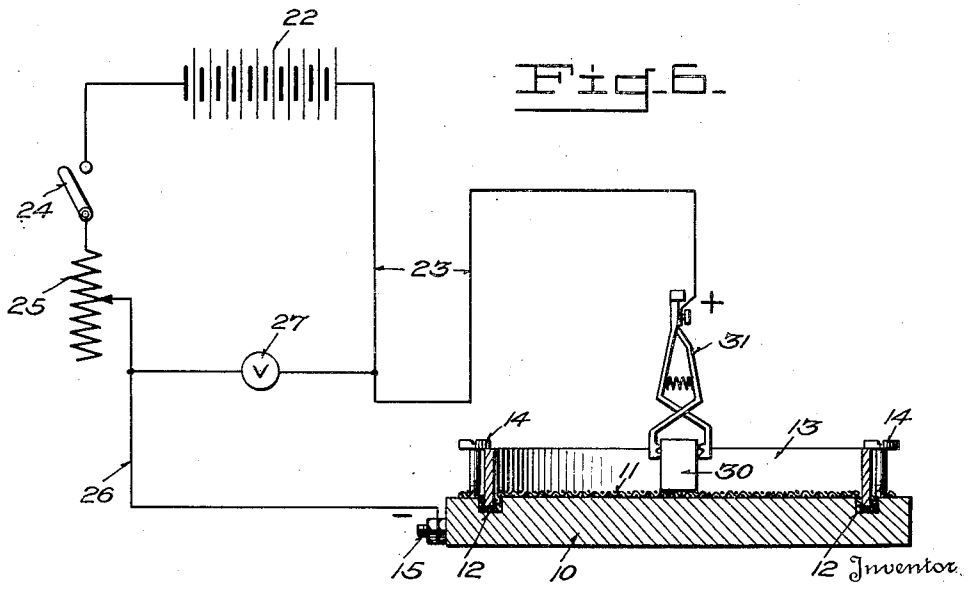


Fig. 6.



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ELECTROLYTIC POLISHING OF METALS

Joseph Mazia, Philadelphia, Pa.

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5 Claims. (Cl. 204—140.5)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to electrolytic polishing of metals.

By electrolytic polishing of metal is meant the imparting of a lustrous finish or mirror-like surface to metal by the conjoint action of a suitable electrolyte and direct electric current passing from the metal undergoing polishing to the electrolyte and then to an electrode in contact with the electrolyte. In this description, and in the appended claims, a direct electric current, during an electrolysis, is considered as flowing from the anode through the electrolyte to the cathode. In the electrolytic polishing of metal referred to above, there is actual smoothing of the metal surface. Light incident upon an electrolytically polished surface experiences regular or specular reflection in contrast to irregular or diffuse reflection which occurs when light strikes a rough or mat surface.

Heretofore, electrolytic polishing has been performed by immersing or submerging the metal to be polished in a bath of a suitable electrolyte, and passing a direct electric current from the metal, as anode, through the electrolyte to a cathode also immersed in the bath. Agitating or vibrating the metal or work during the electrolysis has been found to be advantageous in avoiding streaks, undulations and coruscations. Various electrolytes for use in electrolytic polishing have been proposed, and indeed the trend of the art of electrolytic polishing has been mainly in the direction of developing of suitable electrolytes for use as the bath. Orthophosphoric acid, mixtures including orthophosphoric acid, and mixtures of acetic anhydride and perchloric acid have been proposed and used in the past with considerable success as the electrolyte for the bath.

It is to be appreciated here that electrolytic polishing involves something more than a mere electrolysis performed with the work (the metal to be polished) as the anode. Every electrolysis does not necessarily result in the specular polishing of the metal. Although metal may be dissolved from the work during an electrolysis, the result may or may not be the production of a lustrous or mirror-like surface. The electrolyte must be suitably chosen to fulfill the conditions required of it for obtaining a polished surface. The electrolyte must be one which causes the ridges or high points of rough, dull, or mat metal surfaces to dissolve away faster during the electrolysis than the metal in valleys or depressions between the ridges or high points. As the ridges or high points are dissolved away and become less in height, the metal surface becomes more lustrous, polished or mirror-like. Such an electrolyte is referred to herein as an electrolytic polishing electrolyte in order to distinguish it from electrolytes generally, and it may consist of one or more chemical substances.

2

Electrolytic polishing is therefore to be carefully distinguished from electrolytic etching and electrolytic cleaning of metals. In electrolytic etching of metal, the work or metal to be etched is made the anode in an electrolytic cell and metal is caused, by the flow of the electric current, to be dissolved away from the work without improving the specular reflecting characteristics of the resulting surface. The resulting surface is a mat one and more or less resembles the dull surface obtainable by treating a metal surface with an acid capable of dissolving the metal. Electrolytic cleaning is concerned with removing surface contaminations, such as oxides and grease or oil, from metals. Although some metal as such may be dissolved from the metal during electrolytic cleaning, the resulting metallic surfaces obtained in the past have not been improved in lustrous or mirror-like characteristics.

Among the objects of the present invention is the provision of a new and improved process of electrolytically polishing metals which enables the metal or work to be polished without the use of the conventional bath or body of electrolyte referred to above.

Another object of the present invention is the provision of a process which enables the electrolytic polishing of discrete, localized, or selected areas of large, heavy or cumbersome objects which are not readily amenable to either mechanical polishing or to electrolytic polishing involving immersion in a body of an electrolyte contained in a tank or other suitable container.

A further object of the present invention is the provision of a process for electrolytic polishing of metal which can be used to polish large or small objects without immersing or submerging the object in an electrolyte.

A further object of the present invention is to provide a process for electrolytic polishing of metal in which control of the temperature of the electrolyte during polishing is not required. In the so-called "tank" method which utilizes a body of electrolyte in which the work to be polished is submerged or immersed, careful con-

trol of the temperature of the electrolyte is necessary in most instances of polishing.

A further object of the present invention is the provision of a process of electrolytic polishing of metal which can be effectively controlled during use by the mere regulation of an applied voltage.

A further object of the invention is to provide a process for quickly and easily electrolytically polishing metals.

A further object of the present invention is to provide an effective and rapidly acting process for preparing metallographic specimens with a smooth mirror-like or polished surface, whether as a preparatory step to etching in the determination of grain size, or as a preparatory step for any other purpose.

In the present invention the work or metal is made the anode in a circuit of direct current electricity, but the work is not required to be immersed or submerged in the electrolytic polishing electrolyte as in the "tank" method of electrolytic polishing, nor is a "bath" of electrolyte employed within the ordinary meaning of that term. According to the present invention a thin layer of an electrolyte suitable for use in electrolytic polishing is applied in any suitable way to the metal object or area of metal surface to be polished, and a direct current of electricity is passed from the metal object through the thin layer of electrolyte to an electrode in electrical contact with the said thin layer of electrolyte but out of electrical contact with the metal object or area of metal surface. The current path from the anode, the work or metal to be polished, to the cathode is, therefore, very short in the present invention. While the electric current is passing across the thin layer of the electrolyte from the work as the anode to the cathode, the work and cathode are moved relative to each other, so that during the said relative motion the said thin layer of electrolyte is present between the metal being polished and the cathode.

An advantageous and effective manner of applying the thin layer of an electrolytic polishing electrolyte to the metal surface, and at the same time establishing in contact therewith a cathode held apart from the work to prevent short circuiting, is to face or envelop the cathode with a thin layer of liquid-retentive or liquid absorbent, material, then to impregnate or saturate the said material with the electrolyte and then to bring the metal surface to be polished and the so covered cathode together while a difference of direct current electrical potential exists between the work, as anode, and the covered or enveloped cathode. The thickness or thinness of the liquid-retentive material on the cathode automatically determines the thickness of electrolyte through which the current passes in going from the anode to the cathode. The facing or envelope of liquid-retentive material is fixed or attached to the cathode so that during the relative motion between the work or anode and the cathode, the thin layer of electrolytic polishing electrolyte is maintained between the work and cathode. The liquid-retentive, or absorbent material, in the absence of the impregnating or saturating electrolyte, is a non-conductor of electricity. Glass cloth, glass wool, asbestos cloth or asbestos wool are suitable materials for use for facing or enveloping the cathode. The thickness of the glass or asbestos cloth or wool applied between the work and the cathode may range from 0.003 to 0.250 inch in practical application of the invention.

The liquid-retentive material on the cathode may be impregnated with the electrolytic polishing electrolyte by dipping the cathode into a body of the electrolyte or by feeding of electrolyte to the solution-retentive material intermittently or continuously in regulated or regulable amounts.

The relative motion between the work, forming the anode, and the cathode, carrying the liquid-retentive material, may be brought about (1) by moving the cathode over the surface of the metal or object to be polished, or (2) by moving the object to be polished over the cathode, or (3) by moving both the object and cathode. The motions may be imparted either manually or by suitable mechanical means. In the second and third methods of applying relative motion, the cathode may consist conveniently of a disk or flat plate of an electrically conducting material such as copper, brass, or steel, over which is stretched one or two layers of glass cloth of a thickness of from 0.003 to 0.005 inch.

In general, inorganic materials of the type of glass cloth or glass wool and asbestos cloth or asbestos wool are preferred in the practice of the invention, since materials of this type are more resistant to strong acid electrolytes than cloth, wool or felt of animal or vegetable fibres. The use of solution-retentive inorganic materials in the practice of the invention gives very good polishing results. Wool and cotton woven materials or fabrics also give good polishing effect, although these materials are more subject to disintegration or decomposition by strong electrolytes than wools, cloths, or woven fabrics of inorganic material. Organic materials should not be used with electrolytic polishing electrolytes containing perchloric acid, because of the explosion hazard engendered thereby.

The present invention is not confined in its practice to the use of any particular electrolytic polishing electrolyte. The electrolytic polishing electrolyte will be, or should be chosen, according to the metal or alloy to be polished. An electrolyte that may be suitable for electrolytic polishing of one metal may not be suitable for use in electrolytically polishing a different metal.

A suitable electrolyte for electrolytic polishing of copper, 90/10 gilding metal, 70/30 brass and 60/40 brass according to the invention is composed of 95% by volume of orthophosphoric acid (H_3PO_4) of 1.69 specific gravity and 5% by volume of sulphuric acid of 1.84 specific gravity. With this electrolyte and glass wool or glass cloth, as the facing or envelope of the cathode, good polishing effects were obtained with a voltage of from 8 to 12 volts across the work and the enveloped conducting material of the cathode.

For polishing aluminum according to the present invention there may be employed an electrolyte consisting of seven parts by volume of acetic anhydride and two parts by volume of an aqueous solution of perchloric acid of 1.48 specific gravity, with a potential difference of about 15 volts across the work to be polished and the conducting solid portion or metal of the cathode.

In polishing stainless steel of the 18–8 type, an electrolyte consisting of 80% by volume of 1.69 specific gravity orthophosphoric acid and 20% by volume of 1.84 specific gravity sulphuric acid may be used with a difference of potential across the work and the solid conductive portion of the cathode of about 8 volts.

Plain carbon steel may be polished according to the present invention by utilizing, in its practice, as the electrolytic polishing electrolyte a mixture consisting of 80% by volume of acetic

anhydride and 20% by volume of an aqueous solution of perchloric acid of 1.48 specific gravity. A potential difference of about 7 volts across the work and cathode has given good polishing of plain carbon steel with the aforementioned electrolyte.

In the preceding four examples of electrolytes usable for electrolytic polishing according to the invention, the voltages given apply to operation with thickness of glass cloth of about 0.003 inch on the cathode.

The cathode which carries the solution-retentive material may be an electrically conductive solid material such as steel, copper, brass, nickel, etc. The shape and size of the solution-retentive material and cathode may be varied for application of the process to flat as well as to irregular or configured metal surfaces.

The potential difference that may be applied across the work, as anode, and the cathode, in the practice of the process, may range from 5 to 40 volts, although it is to be understood that the practice of the invention is not limited to the use of this specific range of potential difference.

An important feature of the invention resides in the fact that current densities of a high order are attainable in the practice of the process, even with potential differences as low as 5 to 15 volts across the metal to be polished and the cathode. With potential differences of the order of 5 to 15 volts, current densities of the order of 1000 to 1500 amperes per square foot of anode surface are attainable. This high current density upon the locality or area being polished results is very rapid polishing of the metal.

Another important feature of the present invention is that the temperature of the electrolyte carried in the solution-retentive material or applied by it as a thin layer to the metal surface does not require regulation or control for successful polishing.

It is to be noted that owing to the relative motion between the metal undergoing polishing and the cathode, the thin layer of electrolytic polishing electrolyte upon the metal to be polished is agitated or sheared during the practice of the process. This agitation or shearing breaks up bubbles of gas liberated during electrolysis, whereby the electrical resistance between anode and cathode is held at a low value, and whereby streaks, coruscations and undulations are avoided on the polished surface.

During the polishing of metal according to the present invention, metal is dissolved, as explained above, from the high points of the rough or dull surface. The metal so dissolved enters into the thin layer of electrolyte as dissolved salts. Were it not for the agitation or shearing of the thin layer of electrolyte by the relative motion of the anode and cathode, these salts would tend to form a layer of highly concentrated solution of a salt or of salts immediately adjacent the high as well as the low points of the anode, and this layer, owing to low dissociation of a highly concentrated salt solution, would, without the agitation or shearing, cause a rise in electrical resistance, and in addition would deprive the surface of the metal to be polished of the type of solution necessary for electrolytic polishing. With agitation or shearing of the thin layer of electrolytic polishing electrolyte, the concentrated salt solution is removed preferentially from the high points but retained in the low points. The retention of this concentrated salt solution in the low points retards the dissolution of metal from these points and thereby accelerates the differential action of the electrolytic polishing electrolyte.

Apparatus suitable for use in practicing the invention is illustrated in the accompanying drawings. In these drawings, wherein the same reference numeral indicates the same or like parts.

Figure 1 is a plan view of one form of cathode.

Figure 2 is a longitudinal section on the line 2—2 of Figure 1.

Figure 3 is a plan view of another form of cathode.

Figure 4 is a section on the line 4—4 of Figure 3.

Figure 5 illustrates the application of the invention in electrolytically polishing brass cartridge cases of artillery ammunition.

Figure 6 illustrates the application of the invention in electrolytically polishing or lapping a metallographic brass specimen prior to etching in the determination of grain size.

Referring to Figures 1 and 2, numeral 1 indicates a bar of electrically conducting solid material, such as copper, brass or steel. Around one end of this bar is wrapped a body of glass wool 2, which is secured to the bar by means of copper wire ties 3. At the opposite end of the bar 1 there is provided a binding post or connection 4 for connecting the wire 5 electrically with the bar. The wire 5 may be connected to the negative side of any suitable source of direct electrical current.

The cathode illustrated in Figures 1 and 2 is adapted to be used manually in polishing by manually holding the part of the bar between the binding post and glass wool and rubbing the part enveloped with glass wool over the metal surface to be polished, the glass wool having been previously wetted with an electrolytic polishing electrolyte.

The form of cathode illustrated in Figures 3 and 4 consists essentially of a brass or stainless steel disk 10 and a taut covering consisting of thin cloth 11 made of woven glass threads. The disk 10 is provided with an annular groove 12 somewhat inwardly of its edge. A ring 13 fits somewhat loosely in the annular groove 12. The glass cloth 11 passes under the bottom of the ring 13 in the groove 12. Four screws 14, approximately 90 degrees apart, hold the ring 13 tightly down in the groove 12, by engagement of their heads with the top of the ring 13. The ring 13 serves as clamping means for holding the glass cloth in taut condition on the disk, and as a confining wall for holding electrolytic polishing electrolyte on the disk. Numeral 15 indicates a binding post for connecting the electrical conductor 16 to the disk 10. The conductor 16 may be connected to the negative side of any suitable source of direct electric current.

Figure 5 illustrates a suitable electric circuit for using the cathode illustrated in Figures 1 and 2 in polishing a brass case of artillery ammunition. In this figure the brass case is indicated by the numeral 20, and the cathode of Figures 1 and 2 is indicated by the numeral 21. The positive side of a battery 22, or of any other source of direct electric current, is connected to the brass case 20 by the conductor 23 and spring clamp 24. The negative side of the source 22 of direct electric current is connected through a switch 24, a variable resistance 25, and a conductor 26 with the cathode 21. A voltmeter 27 is connected, as shown, across the conductors 23 and 26 for measuring the potential difference between the metal being polished (the cartridge case) and the cathode 21. In use, the glass wool of the

cathode is wetted with the electrolytic polishing electrolyte and rubbed over the surface of the brass case while the current is flowing. The rubbing of the surface with the wetted glass wool is continued until the desired degree of polishing is obtained.

Figure 6 discloses the use of the cathode of Figures 3 and 4 in polishing or lapping a metallographic specimen 30, for example, a brass specimen preparatory for determination of grain size or microstructural elements by etching of the polished surface and microscopic examination of the etched surface. The electrical circuit in this figure is the same as in Figure 1 and the parts thereof have been indicated by the same reference numerals. The cathode parts in this figure are indicated by the same reference numerals as in Figures 3 and 4. In this use of the invention the positive side of the source of direct electric current 22 is connected by means of a spring clamp 31, or by any other suitable means, with the work 30 (the metallographic specimen) which is moved over the stationary cathode. The disk 10 of the cathode is connected with the negative side of the source 22 of direct electric current by the conductor 26. An electrolytic polishing electrolyte is poured upon the glass cloth 11 of the cathode in sufficient amount to cover it, and then the specimen 30 is rubbed over the surface of the glass cloth. Back and forth and circular motions in this rubbing may be employed, and the rubbing is continued until the desired degree of polishing is obtained.

I claim:

1. In the art of electrolytic polishing of a metal wherein the metal to be polished is subjected to the combined action of an electrolytic polishing electrolyte and direct electric current, with the said metal as anode, the process which comprises producing relative motion between the metal surface to be polished and a layer of electrically non-conducting liquid-retentive fabric material wetted with said electrolyte, while the said fabric material and said metal surface are in contact and while passing a direct electric current from said metal surface through the electrolytic polishing electrolyte wetting the said fabric material.

2. In the art of electrolytic polishing of a metal wherein the metal to be polished is subjected to the combined action of an electrolytic polishing electrolyte and direct electric current, the process which comprises establishing the said metal as a positive electrode in contact with an electrolytic polishing electrolyte, establishing another conductor in contact with said electrolyte as a negative electrode, maintaining between and in contact with said electrodes a liquid-retentive electrically non-conductive means but which nevertheless permits the conduction of electricity between said electrodes by said electrolyte, and moving said electrodes relatively to each other in a direction transverse to their distance apart.

3. In the art of electrolytic polishing of a metal wherein the metal to be polished is subjected to the combined action of an electrolytic polishing electrolyte, with the said metal as anode, the process which comprises establishing the said metal as a positive electrode in contact with an electrolytic polishing electrolyte, establishing another conductor in contact with said electrolyte as a negative electrode, the distance apart of said electrodes not exceeding about 0.25 inch, interposing between said electrodes liquid-retentive electrically non-conducting means to hold the

said electrodes apart but which nevertheless permits conduction of electricity between said electrodes through said electrolyte, conducting direct electric current from said positive electrode to said negative electrode through said electrolyte; and, during the passage of said current, moving said electrodes relatively to each other in a direction transverse to the direction of flow of current between said electrodes.

4. In the art of electrolytic polishing of a metal wherein the metal to be polished is subjected to the combined action of an electrolytic polishing electrolyte and direct electric current, the process which comprises establishing the said metal as a positive electrode in contact with an electrolytic polishing electrolyte, establishing another conductor in contact with said electrolyte as a negative electrode, spacing said electrodes apart by an electrically non-conductive liquid retentive material which permits the conduction of electricity between said electrodes by said electrolyte, and moving said electrodes relatively to each other in a direction transverse to their distance apart.

5. In the art of electrolytic polishing of a metal wherein the metal to be polished is subjected to the combined action of an electrolytic polishing electrolyte and direct electric current, with the said metal as anode, the process which comprises establishing a layer of electrolytic polishing electrolyte between said metal, as anode, and a cathode spaced from said metal at a distance of from about 0.003 inch to about 0.25 inch, said layer on one side making electrical contact with said metal and on the opposite side making contact with said cathode; preventing direct electrical contact between said anode and said cathode by interposing between and in contact with opposed surfaces of them a liquid-retentive electrically non-conductive material which permits the conduction of electricity between said anode and cathode by said electrolyte; passing direct electric current through said electrolyte from said metal, as anode, to said cathode; and during the passage of said current moving said metal and cathode relatively to each other in a direction transverse to the distance between said metal and cathode.

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