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2,933,437

CHEMICAL LAPPING METHOD

Filed May 29, 1956

FIG. 1

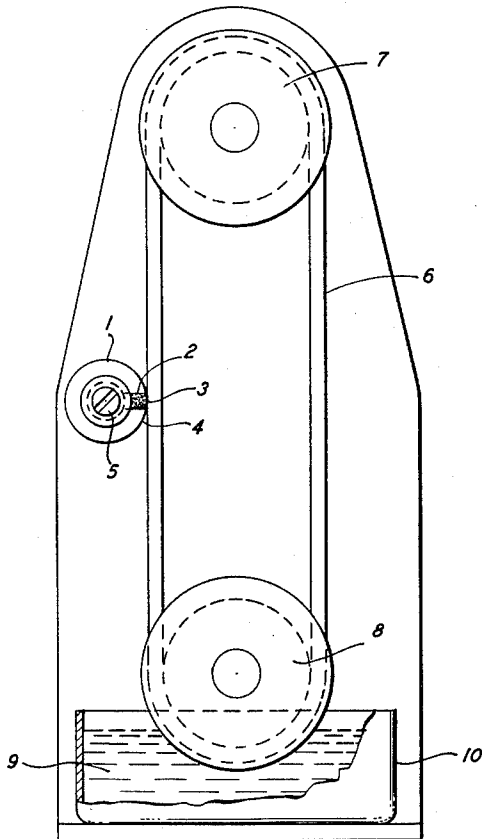


FIG. 2

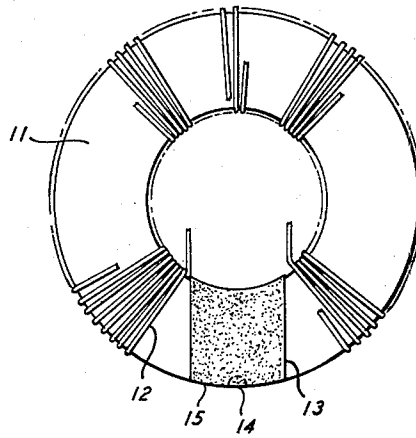


FIG. 3

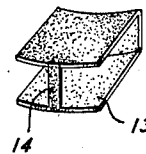


FIG. 4

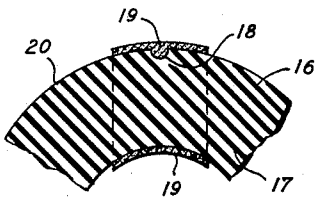
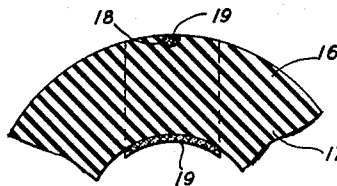


FIG. 5



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2,933,437

CHEMICAL LAPPING METHOD

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8 Claims. (Cl. 204—15)

This invention relates to processes for removing layers of controllable thickness from metal bodies by a combination of chemical reaction and mechanical abrading. In accordance with one embodiment a smooth composite surface of a metal and a supporting material is produced by removing any protruding metal without abrading the supporting material.

In accordance with this invention a metal surface from which a layer is to be removed is first treated with a chemical agent which will react to form a surface layer of a reaction product which is insoluble in the chemical agent, this surface layer having substantially less abrasion resistance than the metal. The surface layer is then removed by rubbing, thereby exposing fresh metal surface. The process is continued until the desired amount of metal has been removed. A smooth composite surface of such a metal and a supporting medium such as a ferrite may be produced without removing any of the supporting medium by rubbing protruding metal with a rubbing material which is abrasive with respect to the reaction product but not the medium.

In a preferred embodiment of this invention, the process is carried out continuously by utilizing a moving endless belt of the rubbing material which is continuously passed through a trough containing the chemical agent and which continuously rubs the metal surface. This endless belt performs two functions in transporting the chemical agent to the surface of the metal and in removing the reaction product so formed.

The nature of the invention will be more clearly understood from the following detailed description and the accompanying drawings in which:

Fig. 1 is a schematic view of one type of apparatus on which the preferred embodiment above described has been carried out;

Fig. 2 is a plan view of a device having a composite, smooth surface produced in accordance with this invention;

Fig. 3 is a perspective view of the metal portion of the device of Fig. 2 produced by a process described herein;

Fig. 4 is a plan view of a portion of a body having a composite surface of a metal and a supporting material before treatment; and

Fig. 5 is a plan view showing the surface depicted in Fig. 4 after treatment in accordance with this invention.

Referring again to Fig. 1, disc 1 may be composed of a ferrite or other supporting medium having a single short-circuit winding 2 of a metal, such as copper or silver, plated on its surface and includes surface 3 of the metal protruding beyond peripheral surface 4 of disc 1. Disc 1 is mounted on spindle 5. Endless belt 6 is driven in a clockwise direction over pulleys 7 and 8 thereby passing through chemical agent 9 in trough 10 and rubbing metal surface 3.

Fig. 3 is a schematic view of a magnetic recording head described in United States Patent 2,677,019. It is presented as an example of a device which is advantageously

manufactured in accordance with a process herein. Toroidal form 11 is the core of the magnetic head and is made of a high permeability, low-loss, magnetic material such as a ferrite. Primary winding 12 may comprise a plurality of turns of low resistance wire, such as enamel-covered copper wire, wound in such manner as to be coupled closely to the core 11 and/or secondary winding 13. Endless secondary winding 13 consists of one turn of a low resistance material such as copper or silver and is terminated in a slender filament 14 of low resistance conducting material which is flush with the surface 15 of the core 11. The method of producing such a secondary winding 13 will be discussed in detail in connection with the description of Figs. 4 and 5. Electrical characteristics of a magnetic head such as that depicted in Fig. 2 and the dependency of these characteristics on the spacing, size and number of turns of the primary and secondary windings are not material to a description of this invention. Information regarding these characteristics may be obtained from the above-cited United States patent.

Fig. 3 is a perspective view of secondary winding 13. Fig. 3 clearly depicts filamentary portion 14 of winding 13 after chemical lapping.

The sectional view shown in Fig. 4 depicts a portion of a device 16 prior to lapping. Device 16 comprises supporting material 17, which, as in the example of the magnetic head of Fig. 2, may be of ferrite material such as zinc ferrite, slot 18 which is ground or otherwise formed in material 17 of device 16, and metal 19 which is electroplated or otherwise deposited over surface 20 of device 16 in such manner as to fill slot 18. In the example shown metallic material 19 is deposited on device 16 in the form of a single short-circuited turn. It is seen that metallic material 19 projects above the surface 20. In this example, it is desired to remove the projecting portion of metallic deposit 19 so as to produce a flush composite surface comprised of filled slot 18 and the ferrite material 17 which surface is coincident with peripheral surface 20.

To accomplish this objective without removing any of ferrite material 17 at surface 20, the device is processed on apparatus such as that depicted in Fig. 1. This surface is rubbed with a member which is non-abrasive with respect to material 17, while continually dampening the exposed portion of deposited material 19 with a reactant which will readily produce a mechanically weak protective coating. If material 19 is copper, a suitable reagent is concentrated aqueous hydrogen peroxide of a concentration of at least 5 percent which reacts with copper to produce a soft cupric oxide layer which is in turn removed by the slight abrading action of the rubbing member. Removal of this coating reveals fresh metal which combines with the reagent to form a new layer. The process is continued until all of excess material 19 is removed. If the rubbing member is fairly stiff, the resultant device will resemble that depicted in Fig. 5.

In accordance with Fig. 5 the treated surface 20 of ferrite material 17 and metallic material 19, the latter now restricted to the filled portion of slot 18 at this surface, is smooth and unbroken. All of the projecting portion of deposited metal 19 has been removed by the lapping procedure. Since hydrogen peroxide does not attack ferrite material 17, none of the supporting member 16 has been removed.

Although the process has been described in terms of forming an oxide layer on copper by reaction with concentrated hydrogen peroxide, many alternatives will suggest themselves to those skilled in the art. As is well known, suitable oxide layers may be formed on copper by use of solutions of potassium or sodium dichromate or by use of solutions of a perborate. For removal of

silver in accordance with the outlined procedure, oxide coatings have been found to be unsatisfactory chiefly by reason of the very slow oxidation rate of silver at room temperature. Silver sulfide which may be formed very readily at room temperature by use of any of a number of well-known reagents such as aqueous ammonium thio-sulfate, is suitable. Such layers may be removed, for example, by use of apparatus such as that depicted in Fig. 1.

Other alternatives for use in the lapping of copper, silver and other metals will suggest themselves. In selecting such alternatives it should be kept in mind that the formed layer should have the following characteristics:

(1) The coating to be formed must be "protective" in that it prevents further reaction below the surface of initial contact. Stated another way, it is necessary that the reaction layer be substantially insoluble in the reacting chemical.

(2) If the metal is in contact with or is supported by a body of another material, and if a smooth composite surface is to be produced without altering the surface configuration of the other material, it is necessary that the reacting chemical not react with the other material.

(3) A protective coating formed should be mechanically weak and be softer than the metal on which it is formed. If the surface is composite, it is a further requirement that the coating also be softer than the other material.

(4) The protective layer should form at such a rate as to make the process economically feasible.

In accordance with this last requirement, many well-known protective layers are eliminated for use in this process. For example, cupric carbonate and cupric hydroxide which, in combination, appear as tarnish on copper, are very slow to form. Cupric oxide on the other hand is rapidly produced at room temperature by contacting the copper with concentrated aqueous hydrogen peroxide. This reaction may be further accelerated by use of a minute amount of cupric nitrate in the hydrogen peroxide solution. As is well known, other salts, for example, cupric sulfate, will perform the same function. The use of less than one-hundredth part by weight of such copper salts in regard to the solution is sufficient.

Use of the apparatus depicted in Fig. 1 has met with satisfactory results in the production of devices such as the magnetic head of Fig. 2. It is to be understood, however, that the use of such an endless belt is merely suggestive, there being occasions in which, for example, hand rubbing or use of a disc or roller will be preferred. Regardless of the form that the abrading mechanism takes, certain requirements are apparent. For example, the abrading material should be non-abrasive in respect to a supporting material or any other material which is to form part of a composite surface with the metal to be removed. The abrading material should be sufficiently abrasive to remove the reaction product and, in general, should also be stiff enough so as not to result in any undue undercutting of the metal element. It should also be smooth and of a material which is inert in respect to the chemical reactant.

Where the metal to be lapped forms part of a composite surface which is non-planar or where for any other reason it is desired to lap the metal element in such way as to produce a curved surface, this may be achieved in a number of ways. If a belt is used, sufficient slack may be provided to allow it to adapt itself to the contour of the body. Alternately, where the composite surface is an arc, a flat belt or other flat abrading member may be used in conjunction with an oscillating body containing the metal to be lapped so as to produce a curved surface. In the production of the magnetic head of Fig. 2 utilized in the apparatus of Fig. 1, satisfactory results have been obtained by oscillating disc 1 on spindle 5. In this particular apparatus disc 1 was caused to oscillate over an

arc of about 15 degrees corresponding with the segment 2 of deposited metal.

An actual example relating to the manufacture of the magnetic head of Fig. 2 is given below:

Example 1

A body of zinc ferrite is ground into a toroidal form having an outside diameter of $\frac{3}{8}$ inch, an inside diameter of $\frac{5}{16}$ inch and a thickness of $\frac{3}{4}$ inch. A fine slot 3 mils deep and 2 mils wide and substantially parallel to the axis of the toroid is cut in the outside surface. The entire core is then flash-coated with silver and then with a very thin electrodeposited copper coating. The toroid is masked with a stop-off lacquer such as nitrocellulose lacquer to form a single short-circuited turn around the core, the exposed area including the grooved portion of the toroid. A copper plating about 3 mils thick is then applied to the core after which the stop-off lacquer is removed with a suitable solvent such as acetone. The copper coating over all but the short-circuited turn is removed by reverse plating and the silver, now in the form of silver chloride, is removed by a quick dip in a bath of concentrated ammonia and nitric acid.

At this stage in the operation, the portion of the magnetic head here of interest resembles Fig. 4. The member is then mounted on a spindle such as 5 of the apparatus of Fig. 1 which in turn is attached to an oscillating mechanism so geared as to cause the member to oscillate through an arc of about 15 degrees. A straight rubber belt such as belt 6 of the apparatus of Fig. 1, about one-half inch wide and one-eighth of an inch thick is driven by means of a mechanism, not shown, at a rate of about 625 inches per minute through a trough containing "Superoxol" (a concentrated aqueous hydrogen peroxide solution of nominal 30 percent concentration) so as to contact the plated portion 19 of the oscillating head. The protruding portion of the deposited copper layer which was about $2\frac{1}{2}$ mils thick was removed in about a half hour to produce a surface such as that shown in Fig. 5.

What is claimed is:

1. A process for removing a protruding portion of a metal region from a body having a composite surface of such metal and another material, comprising repeatedly treating the protruding surface of the metal with a chemical reagent solution, the solution being such that it is substantially inert with respect to the said material and such that it reacts with the metal to form a layer of a compound of the metal which is softer than both the said metal and the said material and which layer is substantially insoluble in the said solution, and rubbing with a smooth substance which is abrasive with respect to the layer but which is substantially unabrasive with respect to both the said metal and the said material, the process being continued until such protruding metal portion has been removed to produce a smooth composite surface of the said material and the said metal, further abrading of the said layer being prevented by the substantial inability of the said substance to abrade the said material.

2. The process of claim 1 in which the metal surface is copper and the chemical reagent is an oxidizing agent which will combine with copper to produce cupric oxide.

3. The process of claim 1 in which the metal surface is silver and the chemical reagent is a sulfiding agent which will combine with silver to produce silver sulfide.

4. The process of claim 1 in which the chemical reagent solution is a concentrated aqueous solution of hydrogen peroxide and in which the metal surface is copper.

5. A process for producing a smooth composite surface of copper and a supporting material comprising indenting a surface of a body of the said supporting material, depositing copper in the indentation in such amount that the surface of the copper protrudes above the surface of the said supporting material, continuously treating the protruding surface with an oxidizing agent which com-

5 combines with the copper to produce a layer of cupric oxide but which does not oxidize the supporting material, rubbing the said layer of cupric oxide with an abrasive material which is abrasive with respect thereto but which is substantially unabrasive with respect to the copper and the said supporting material, the process being continued until the protruding portion of deposited copper has been removed.

6. The process of claim 5 in which the oxidizing agent is concentrated aqueous hydrogen peroxide.

7. The process of claim 6 in which the said rubbing is carried out by means of a moving endless rubber belt of such configuration and under such tension that abrading of the cupric oxide ceases when a flush surface is produced.

8. A process for producing a smooth composite surface of copper and a ferrite comprising indenting a surface of a body of the ferrite, electrically depositing copper in the indentation in such amount that the surface of the copper protrudes above the surface of the said ferrite, continuously treating the protruding surface with

an aqueous solution of hydrogen peroxide, which combines with the copper to produce a layer of cupric oxide, rubbing the said layer of cupric oxide with rubber, the process being continued until the protruding portion of deposited copper has been removed.

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