Nov. 10, 1964 H. CHESSIN ETAL 3,156,632

METHOD OF APPLYING PARTICLES TO AN ELECTROFOAM DURING ELECTROPLATING

Filed Feb. 11, 1960

FIG. 1

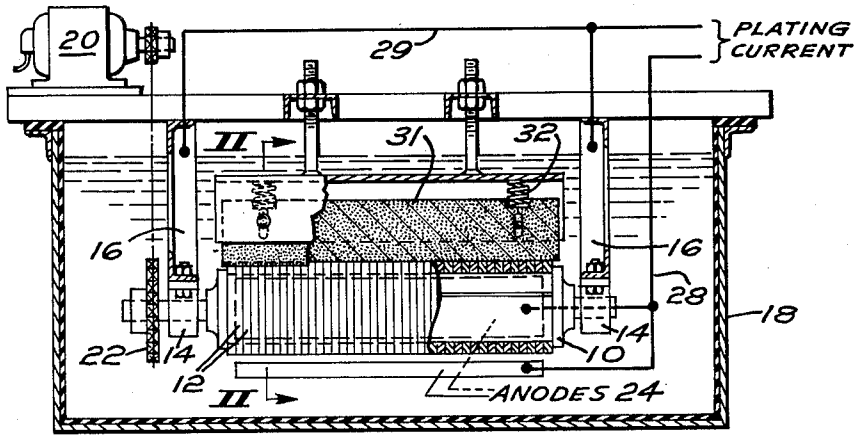


FIG. 2

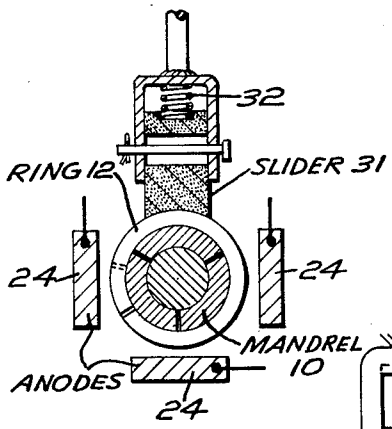


FIG. 3

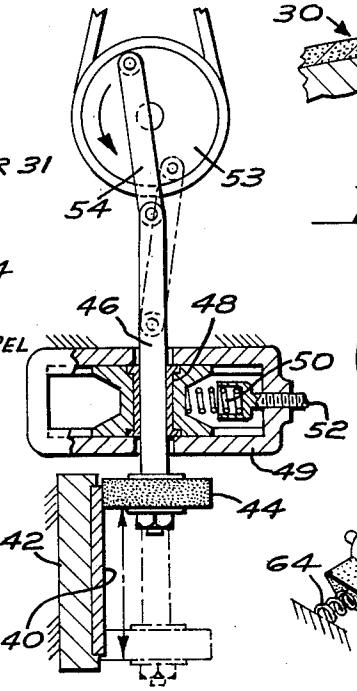


FIG. 6



FIG. 4

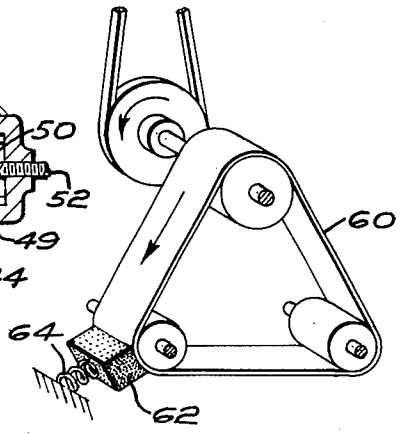
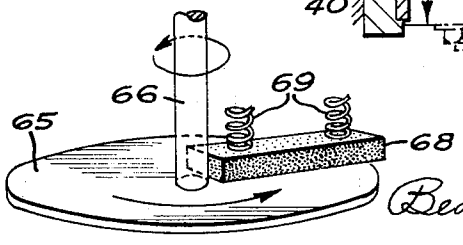


FIG. 5



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United States Patent Office 3,156,632 Patented Nov. 10, 1964

3,156,632

METHOD OF APPLYING PARTICLES TO AN ELECTROFOAM DURING ELECTROPLATING

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Filed Feb. 11, 1960, Ser. No. 8,074
7 Claims. (Cl. 204—16)

This invention relates to improved electroforms and method for producing the same; said electroforms being of composite nature comprising electroplated matrix material embodying other particulate material inclusions therein.

It has been long considered desirable to be able to produce electroforms having specified properties such as inherent lubricity, or high wear resistance, or the like; such as for example in the case of piston rings or other bearing surfaces. In other cases it is required to provide inherent abrasiveness, such as for example in the case of abrasive rolls or discs or other abrasive structures; in any case the prime objective being to give the finished product the basic properties of the matrix metal, such as strength or lightness or cheapness, in addition to the surface properties desired for the composite material.

Previously employed methods utilized for such purposes include the conventional metal spraying, electrophoresis, and hot pressing techniques, but have resulted in only limited success. Spraying of metals or of metals composite with other materials has proven to be unsuitable for such purposes because the coherence and adherence of the components of the sprayed deposits are insufficient to withstand severe mechanical and thermal stresses. The same is true of the results obtained by the hot press-coating technique. Electrophoresis techniques require extremely high temperature treatment, usually in a reducing atmosphere, to make the deposit adherent and coherent. Hence such processes are relatively costly and tend to cause warpage deformations and/or other damage to the basis material. For example, use of this technique would tend to anneal or remove "temper" from a previously heat-treated piston ring blank.

Electrodeposition techniques have been previously utilized to form composite coatings, and have the advantages of forming coherent and adherent coatings without the necessity for use of high temperature reduction processes, or the like. Particulate materials have been coincidentally incorporated in electrodeposit, for example by suspending the particles in the plating solution. However, such techniques are of only limited commercial feasibility because it is difficult to maintain particles in suspension in a plating bath, and because constant or frequent filtration of a plating bath is necessary to obtain deposition of good quality electroplates. It is obvious that filtration of a plating bath to which suspension materials have been added will defeat the purpose of the additive. Furthermore, coatings produced by such methods have been found to be inherently highly porous.

For example, colloidal graphite has been suspended in copper, nickel and zinc plating baths to form composite coatings of varying porosities. Whereas porosity of substantial degree may be tolerated or even desirable in some cases, it is obvious that the higher the percentage of voids in the coating, the weaker will be its tensile and shear strengths. Furthermore, the suspended particles used in connection with such techniques must be chemically inert so far as the plating bath is concerned. This definitely limits the choice of materials which may be incorporated in the composite electroplate coating by any such "suspension" techniques.

The present invention provides a superior method whereby any material chosen for its desirable properties may be incorporated in an electrodeposit to form a composite body or coating of superior physical properties. Generally stated, the method involves moving the surface which is being plated in pressure-bearing relation against a solid mass which contains the material to be incorporated within the plate, so as to cause attrition of the mass and progressive wiping of particles of the material of the mass into the plate being formed. These particles are thus bound to the dynamic surface by the plating metal and become intimately incorporated within the plate as it continues to grow.

The mass material may for example be in the form of a solid metal, such as lead or silver, which will wear away by the relative motion of the mass and the plating surface. However, the mass may comprise an agglomeration of particulate matter of powder or fibre forms for example, suitably bound or compacted into a solid mass. Materials suitable for inclusion as lubricity agents for example are lead, tin, molybdenum disulfide, and graphite. Materials suitable for inclusion as abrasive agents for example, are silica, silicon and tungsten carbides, alumina, molybdenum disilicate, and diamond dust or grit. These materials may be incorporated in a solid slider mass by compaction, with or without heat, and with or without a suitable binder material. Suitable binder materials include for example glues or synthetic plastics such as the thermoplastic methacrylates which can be mixed with the particulate matter in powdered form; the resultant mixture being then compacted into solid form by the application of moderate heat and pressure. Thermosetting plastics may be similarly used. Also, it has been found convenient to use the catalyst-setting plastics, such as the epoxies, since the particulate matters are readily mixed with such plastics in simple molds of convenient size and shape to solidify. It is a feature of the present invention that the composites so formed may comprise mixtures of different kinds of particulate matter as well as being formed of a single kind.

As a specific example, we have produced a composite coating suitable for piston rings by utilizing a slider consisting of 40% by weight of molybdenum disulfide, 40% by weight of powdered tin and 20% by weight epoxy resin binder. This slider was forcibly pressed against a rotating cylinder, a facsimile of several adjacent piston rings on a mandrel. During this process iron was being plated onto the surface from a commercial bath. The resulting coating consisted of a composite of molybdenum disulfide and tin particles distributed throughout an electrodeposited iron matrix. Analysis showed that the electrolytic iron plated with the slider in contact contained 0.205% of carbon, 0.12% tin and 0.09% molybdenum (or 0.15% molybdenum disulfide); identical electrolytic iron deposited without the slider in contact with the plating surface contained 0.048% carbon, 0.011% tin and 0.007% molybdenum. The wear and non-scuffing, non-galling compatibility of the slider-treated coating is superior because of the self-lubricating properties of the coating, this self lubricity being endowed by the particles distributed throughout the coating.

Another example of the use of this method includes the forming of an abrasive disc by rotating the disc as the cathode in a nickel plating solution and pressing thereon a solid slider consisting of 80% by weight alumina and 20% by weight methyl methacrylate. As a result the coating will consist of a composite of abrasive alumina particles embedded throughout a nickel matrix.

Another example to illustrate the range of properties which may be obtained is the coating of shafts by plating in a nickel bath while the shaft is rotating against a slider consisting of 80% by weight tungsten carbide and 20%

by weight of "Bakelite." The resulting composite coating will have excellent wear and scuff-resistance.

Types of mechanisms which may be used in carrying out the invention are illustrated in the accompanying drawing wherein:

FIG. 1 is a partially schematic vertical sectional view through a plating tank and apparatus for practicing the method of invention in conjunction with cylindrically surfaced workpieces, such as a "gang" of piston ring blanks;

FIG. 2 is an enlarged scale sectional view taken on line II—II of FIG. 1;

FIG. 3 is a fragmentary view of another form of apparatus for practicing the method of the present invention in connection with flat or curved workpieces;

FIGS. 4, 5 are schematic illustrations of still other forms of apparatuses for practicing the invention on various kinds of workpieces; and

FIG. 6 is a fragmentary sectional view, on greatly enlarged scale, illustrating the nature of a composite coating product of the method of the invention as applied to a curved surface workpiece.

As shown for example in FIG. 1 of the drawing herewith, the apparatus thereof is arranged to surface-coat gangs of ring-shaped workpieces, such as engine piston rings, to furnish the latter with wearing surfaces of improved lubricity and wear resistant characteristics. In this case a mandrel as indicated at 10 is arranged to mount therearound a plurality of piston ring blanks 12 in side-by-side stacked relation; the mandrel 10 being journalled as indicated at 14 upon hangers 16, thereby suspending the mandrel within a plating tank 18. A motor 20 and suitable chain and sprocket drive means or the like as indicated at 22 is provided to cause rotation of the mandrel.

Anodes comprising bars or plates of the matrix metal or material to be plated on the workpieces as indicated at 24 are disposed alongside the mandrel and ring assembly, and are connected as through a common conductor 28 to the plating current supply. Another conductor 29 connects to the brackets 15, 16 carrying the mandrel 10, thereby making the workpieces 12 the cathode elements of the plating system. Thus it will be appreciated that upon supplying of a suitable plating solution in the tank 18 and application of plating current to the conductors 28, 29, an electroplating process will be established to plate the matrix material of the anodes on the workpieces in accord with the well known principles of the plating art.

In accord with the present invention however, a second supply of material is to be embodied in the matrix material of the composite coating to be applied to the workpieces. In the case of FIG. 1 this material source is provided in the form of a block 31 of particulate material or materials, the particles of which are to be incorporated within the material being plated as the process advances. In accord with the invention the block 31, comprising a compaction or otherwise bonded-together agglomeration of particulates, is mounted in slide-bearing relation against the periphery of the gang of workpieces 12 as they rotate; the block mounting arrangement being shown to include a spring device 32 arranged to permit the block 31 to move relative to the mandrel and workpieces in response to building up of the electroplate as the electroform operation progresses. Thus it will be appreciated that as the plating of material on the surfaces of the rings 12 progresses, particles 34 from the block 31 are simultaneously being worked into the electroform (FIG. 6).

FIGS. 3, 4, 5, illustrate other specific examples of mechanisms for practicing the method of the invention in connection with variously shaped workpieces. For example, in FIG. 3, the workpiece in the form of a flat plate as indicated at 40 may be held in a jig 42 while submerged in an electroplating tank, while the source of particulate material to be embodied in the electroform may be supplied in block form as indicated at 44 and mounted upon

a shaft 46 journalled in a bearing 48 which is mounted for reciprocation in directions normal to the workpiece by means of a slide bearing block 49. A compression spring 50 is provided to furnish the preferred degree of pressure between the block 44 and the workpiece 40; the spring tension being adjustable by means of a screw device 52. To distribute the particulate inclusion treatment over the expanse of the workpiece 40 the shaft 46 may be arranged for vertical reciprocation in the bearing 48, as by means of the pulley and connecting rod arrangement indicated at 53, 54. Similarly, horizontal relative movements between the workpiece 40 and the wheel 44 may be provided for if desired by any suitable means for reciprocating either the workpiece of the block.

FIG. 4 illustrates application of the method of the invention to treatment of a workpiece 60 which is of web or band form, running over appropriate guide pulleys and then in friction bearing contact relation with a block of particulate material as indicated at 62; a spring 64 being again employed to maintain the proper pressure bearing relationship between the workpiece and the block.

FIG. 5 illustrates schematically a device for treating a disc-shaped workpiece 65 in accord with the method of the present invention; the workpiece being mounted upon a driving spindle 66 and being subjected to a particulate material supply block 68 backed up by springs 69 for the purpose of including particulate material in the electroform progressively as it is plated upon the workpiece. It is to be understood that in all cases the particulate material supply member may either be in friction bearing contact with the electroform being produced at a portion thereof which is submerged in the electroplating solution, or alternatively the particulate material supply member may be mounted clear of the plating solution while the workpiece is rotated so as to bring portions thereof alternately into the plating solution and thence into friction bearing relation with the material supply block. Thus, it will be appreciated that whereas only a few forms of apparatus for performing the method of the invention have been schematically illustrated and described, the arrangements shown herein are by no means inclusive of all possible types of apparatuses for the purpose, and that various changes may be made therein without departing from the spirit of the invention or the scope of the following claims.

We claim:

1. The method of providing a composite material body comprising electroformed material having other discrete material embedded therein, said method comprising subjecting a base member to an electroplating operation while disposing in rubbing contact thereagainst a cohesive mass of particulate material, the pressure bearing relationship therebetween being such as to cause particles of said particulate material to detach from said cohesive mass and to become embedded within the electroform as it progresses.

2. The method of providing a composite material body comprising a matrix of electroformed material having other material particles included therein, said method comprising conducting a progressive electroplating operation while disposing in slide-bearing relation thereagainst a cohesive mass of the other material particles, the pressure-bearing relationship therebetween being such as to cause particles of said other material to detach from said mass and to become embodied within the electroform so made.

3. The method of providing on a workpiece a composite material body comprising a matrix of electroformed material having inclusions of other material particles, said method comprising subjecting the workpiece to an electroplating operation while disposing in friction-bearing relation thereagainst a cohesive mass of the other material particles, the pressure-bearing relationship therebetween being such as to cause particles of said other

material to detach from said agglomeration and to become embedded within the electroplate matrix as it forms.

4. The method of forming a composite material body comprising

(*a*) a matrix of electroformed material having discrete particles of other material included therein, which comprises

(*b*) electrolytically depositing the matrix material upon a body, and

(*c*) simultaneously forcibly interlocking particles of the other material with the surface of the matrix by forcing abrading the matrix with a cohesive mass of particles of the other material.

(*d*) and continuing the electrolytical deposition to affix the particles to the matrix.

5. The method according to claim 4 wherein

(*a*) the application of particles is confined, at any instant, to an area less than the surface area of the body,

(*b*) the particles being progressively applied over the entire surface area of the body.

6. The method of forming a composite material body comprising

(*a*) a matrix of electroformed material having discrete particles of other material included therein, which comprises

(*b*) electrolytically depositing the matrix,

(*c*) simultaneously transferring discrete particles of the other material from a cohesive mass thereof to the matrix, and

(*d*) continuing the electrolytic deposition of the matrix to affix the particles of the other material therein.

7. The method of forming a composite material body comprising

(*a*) a matrix of electroformed material having discrete particles of other material included therein, which comprises

(*b*) electrolytically depositing the matrix,

(*c*) simultaneously forcibly applying discrete particles of the other material to the matrix, by forcibly abrading the matrix with a cohesive mass of particles of the other material, and

(*d*) continuing the electrolyic deposition of the matrix to affix the discrete particles therein.

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