May 26, 1970 G. STEPHAN ET AL 3,514,389

APPARATUS FOR PRODUCING A WEAR-RESISTANT SURFACE ON A WORKPIECE

Filed Sept. 6, 1968 2 Sheets-Sheet 1

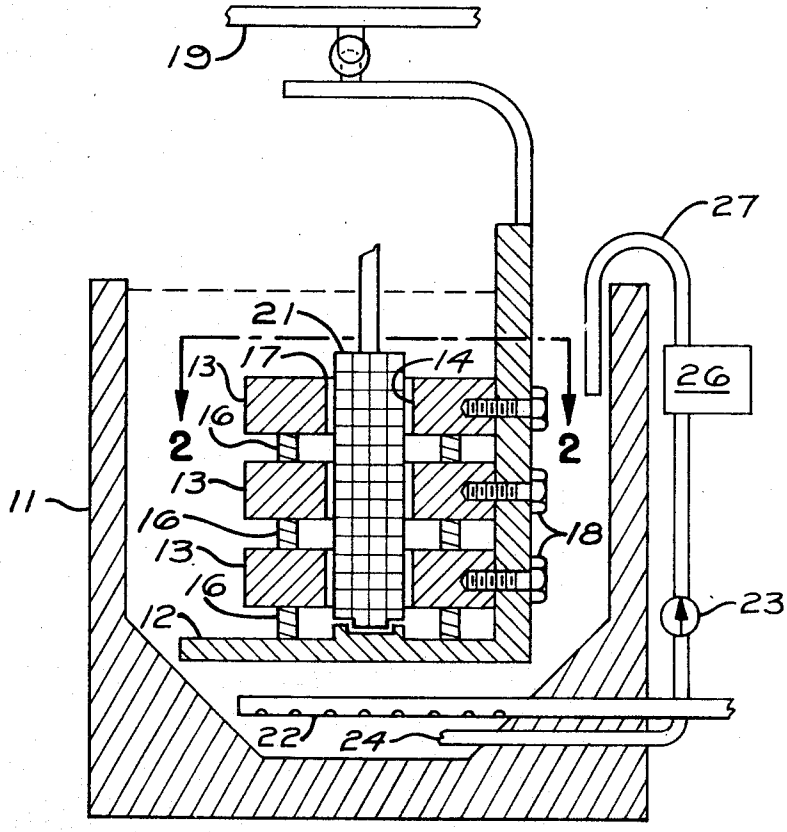


FIG. 1

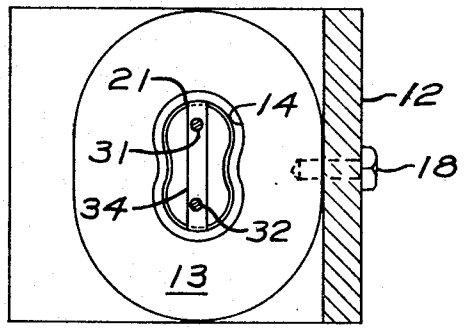


FIG. 2

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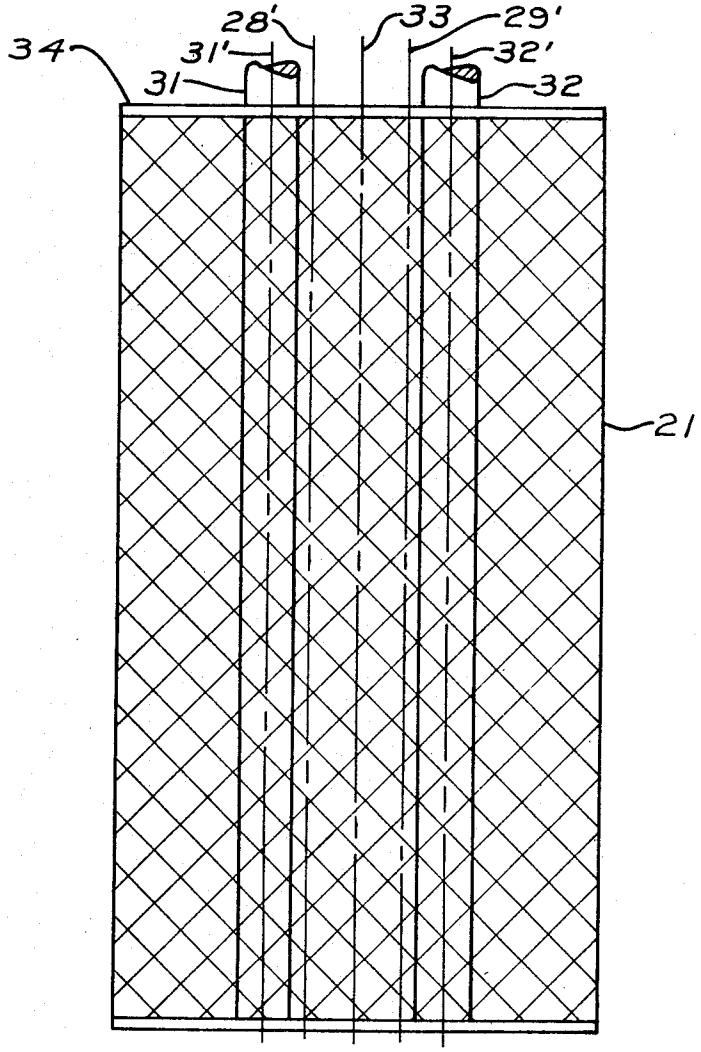


FIG. 3

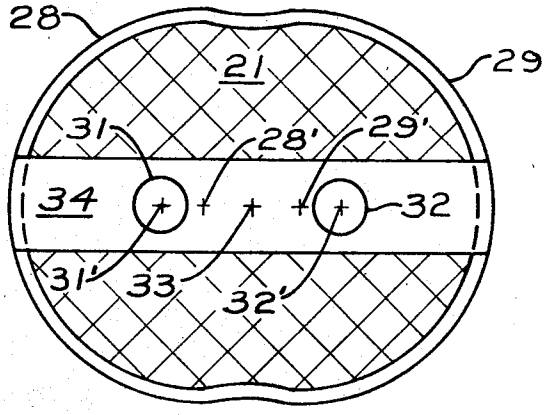


FIG. 4

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APPARATUS FOR PRODUCING A WEAR-RESISTANT SURFACE ON A WORKPIECE

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Int. Cl. B01k *3/04;* C23b *5/70, 5/74*
U.S. Cl. 204—237 4 Claims

ABSTRACT OF THE DISCLOSURE

A process and apparatus for galvanic deposition on a workpiece, particularly the inner surface of trochoidal engine housings, of a metal matrix containing dispersed particles, for the purpose of improving wear-resistance of highly stressed surfaces.

BACKGROUND OF THE INVENTION

The inner surface of the peripheral housing of a trochoidal engine is continuously swept by the sealing elements of the rotor. This action results in wear of the housing surface, and particularly where the housing is formed of a light metal such as aluminum or its alloys the wear may result in some loss of sealing action, with consequent leakage of gas and loss of power. It is therefore advantageous to provide this inner surface with a hard, smooth, wear-resistant coating.

Galvanic processes for plating a hard metal onto a softer one are well known. It is also known to produce a hard surface on a metal by flame-spraying it with molten particles of a harder metal. It is further known, as disclosed in U.S. Pat. No. 3,061,525, to deposit by electroplating methods a metal plate containing particles of another substance, particularly upon flat or externally curved surfaces.

All these processes have drawbacks. Ordinary electroplating is limited to those metals which plate out readily and which are also hard. Flame-spraying is expensive and difficult to control, and requires extensive subsequent finishing operations. The process of Pat. No. 3,061,525 is slow, and is limited to flat objects on which particles can settle, or to externally curved objects which can be rotated during processing to receive settling particles. This is not only cumbersome, but does not readily provide a uniform content of solid particles per unit area.

SUMMARY OF THE INVENTION

The basic achievement of the invention is a process and apparatus for producing on a workpiece, particularly a piece having internal curvature, a uniform coating comprising a metal matrix having embedded and interlocked therein dispersed particles such as various carbides or oxides, for the purpose of imparting superior wear-resistance to the suface of the workpiece. It is important that good adhesion of the coating be maintained, and that the process be rapid in order to provide high output and minimize expense.

The workpiece may first be given, by any of various well known processes, a light flash of zinc in the neighborhood of 1 micron thick. Then the workpiece is put into a

nickel sulfamate plating bath of the composition and under the conditions given hereinbelow, with the surface to be coated facing an electrode having a surface generally congruent and generally parallel to the surface to be coated. The bath also contains minute particles of the hard material which is to form the dispersed phase of the resultant matrix.

With the bath at rest and the particles having principally settled to the bottom, the workpiece as cathode is given a thin plate of nickel at a low current density, which will promote superior adhesion of the nickel. Since the hard particles have largely settled out, only a negligible number will adhere to the plating at this step in the process. Following this, the bath is agitated by suitable means to put the particles into suspension, and the current is increased to a high density. The particles now coming into contact with the plated surface adhere to it and are fixed in place by additional nickel ions which are now plating rapidly, thus forming a metal matrix of uniform thickness and having a dispersed phase of hard particles to form a hard and wear-resistant coating on the workpiece.

It is therefore an object of this invention to provide a process for producing a hard and wear-resistant surface on a workpiece.

It is a further object to provide apparatus and method for producing such a surface in uniform thickness on internally curved workpieces.

Another object is to provide a method and apparatus for producing a metallic matrix having a dispersed phase of hard particles.

Other objects and advantages of the invention will become apparent on reading the following specification in connection with the appended drawings.

Brief description of the drawings

FIG. 1 is an elevational cross-section of equipment and workpieces;

FIG. 2 is a plan view taken on line 2—2 of FIG. 1;

FIG. 3 is an elevation of a basket electrode of suitable configuration; and

FIG. 4 is a plan view of the electrode of FIG. 3.

Description of the preferred embodiment

An apparatus for carrying out the process is shown by way of example in the drawings. The apparatus comprises a tank **11** in which is positioned a supporting frame **12**, on which are positioned a plurality of workpieces **13**. In the example shown the workpieces are peripheral housings for rotary engines, it being desired to coat their inner trochoidal surfaces **14**. The housings are therefore stacked vertically in line, held apart by spacers **16** a convenient distance such as approximately a half inch, in order that the deposited coating will extend slightly over the corner edges **17** of the inner surface. The housings may be rigidly attached to the frame **12** as by bolts **18** or other suitable means to insure that their inner surfaces are congruent.

The supporting frame **12** is pivotally supported from a bridging member **19** in such a manner that it can be swung to and fro in the bath by any suitable means (not shown). In the interior space of the housings, defined by the inner peripheral surfaces **14**, there is positioned an inner anode **21**. Anode **21** has a circumferential space corresponding substantially to that of the surface which is to be coated, and sufficient vertical extension to protrude slightly from both top and bottom of the stack

of workpieces. The anode is a titanium basket, and in the example shown has a generally trochoidal circumference. It contains pieces of the metal to be deposited galvanically, nickel in the present instance.

The bottom of the tank **11** may be slightly funnel-shaped, and in any case has sufficient depth below the frame **12** to allow settling of the dispersed particles. Extending into the bottom portion of the tank is a series of perforated tubes **22**, by means of which compressed air may be blown into the bath for the purpose of keeping it in continuous agitation. There is also provided a pump **23** external to the tank, having a suction tube **24** extending into the solution, and feeding a regenerator **26** from which another tube **27** returns to the bath. By this means the bath can be recirculated for the purpose of keeping it in motion, or for regeneration if necessary.

FIGS. 3 and 4 show an example of the anode basket **21**, formed preferably of titanium, which is resistant to the electrolyte. The basket has a generally epitrochoidal configuration, and may for convience of manufacture be formed as two intersecting cylindrical sections **28** and **29**, which approximate the epitrochoidal form. The basket is open at the top and can be loaded from above with metal fragments, such as nickel when that is the material to be plated out. The metal clippings or other pieces may be enclosed in a bag within the basket, which retains impurities and small bits of metal which result from electrolytic decomposition of the plating material. Such a bag is of fine mesh weave and formed of fibers which are resistant to the electrolyte used, as is common in the plating industry.

Two rodlike conductors **31** and **32** extend from the bottom of the basket and project from the top generally parallel to the longitudinal middle axis **33** of the basket and tied together across the top of the basket by a support member **34** extending across the major diameter of the basket. The two conductors **31** and **32** have their longitudinal axes **31'** and **32'** positioned on the major diameter of the basket, and radially outside the longitudinal axes **28'** and **29'** of the two partial cylinders **28** and **29**. The amount of such displacement of the electrode axes from the centers of curvature of the cylindrical sections is small, and has been exaggerated in the drawings for clarity of illustration. The amount of displacement is ordinarily from about 5% to about 10% of the radius of curvature. The exact distances of the electrodes from the cylinder axes will depend on the shape and size of the housing surface to be coated. The two conductors are connected electrically parallel, as anode, to a source of direct current (not shown), and the positioning results in a uniform field of equipotential lines of force which ensures uniform coating of the cathodic housing surfaces.

The composition of the plating bath is as follows:

	Grams per liter
Nickel (in nickel sulfamate and nickel chloride)	80–100
Chlorine (in nickel chloride)	2.5–3
Boric acid	20–30
Saccharine	1.5–2.5
Hard particles	90–100

The hard particles may be one of various oxides or carbides, such as silicon carbide, silicon dioxide, aluminum oxide, tungsten carbide, boron carbide, or mixtures of these substances. The grain size of the hard particle powder is preponderantly 1 micron and less, the number of particles greater than 3 microns being not more than 1%.

The electrode basket is filled with pieces of nickel, which may conveniently be squares or clippings. The pH valve of the bath has an effect on the quantity of precipitated solid particles, and in accordance with the invention it should be above 4.5, preferably 5.2. The bath is maintained at a temperature of 50° to 70° C.

With the bath at rest and the particles principally settled out, plating is begun at low current density, below

90 amperes per square foot and preferably at about 18.6. Nickel plate is deposited on the housings as cathode at this low current density, the initial deposit being from 10 to 20 microns thick and preferably about 15 microns, which takes about 20–30 minutes. The low current density promotes good adhesion, and only a negligible number of solid particles is precipitated during this phase.

When the basic layer of nickel has reached the desired thickness, the bath is agitated for the purpose of suspending the solid particles in the electrolyte. This may be accomplished by swinging the suspension frame **12** on its pivot, or by blowing air into the bath through tube **22**, or by means of the circulating pump **23**, or any combination of these. At the same time the current is increased to about 186 amperes per square foot, that is, about 10 times the initial plating rate. The hard solid particles now precipitate on the plating surface, while nickel is plating out at an increased rate, embedding and locking the particles into place. This phase is continued for about 100 minutes until the coating is from 300 to 320 microns thick. The total coating time, including initial preparation of the surface, is about 140 minutes, as compared to about 1100 minutes for chromium plating. The time can be decreased somewhat, since the duration of the coating operation decreases with a rise in current density, which can be varied within wide limits during the second phase of the operation, when solid particles are being deposited. However, more rapid deposition results in some increased roughness of the surface.

The positioning of the housings on the frame **12** may be modified so that the housings are stacked contiguously, with their inner surfaces **14** forming a hollow tube. In such a case the bath may be circulated at a selected flow rate by the pump **23** through the space between the anode and the housings, with the pump discharge tube **27** emptying into the interelectrode space.

Although the invention has been described above in a preferred embodiment it is not limited thereto, but is suited to the coating of other types of workpieces, and various modifications may be made by those skilled in the art without departing from the scope of the invention.

What is claimed is:

1. Apparatus for galvanic application on a workpiece of a wear-resistant coating consisting of a metal matrix containing dispersed particles of a hard solid substance, comprising:

(a) a tank adapted to contain an electrolytic bath of the materials to be coated;

(b) a supporting frame extending into the bath adapted to support a plurality of housing shells having trochoidal contour inner surfaces to be coated and positioned on the supporting frame in a vertical stacking arrangement with their inner surfaces congruently aligned and serving as a galvanic cathode; and

(c) a basket anode having a closed bottom containing pieces of a metal to be galvanically deposited and positioned within the housing shells and having a surface generally parallel to the housing inner surfaces, said basket being formed of two intersecting partial cylindrical sections approximating a trochoidal contour of the housings, the axes of curvature of the two partial cylindrical sections being disposed on the major diameter of the basket, said basket also having two rodlike current conductors extending longitudinally therethrough from the bottom and projecting from the top, the axes of the conductors being disposed on the major diameter of the basket and respectively radially outside the two axes of curvature of the basket sections and parallel thereto.

2. Apparatus as recited in claim **1**, wherein the supporting frame is pivotally mounted for movement in the bath.

3. Apparatus as recited in claim **1**, wherein the individual housing shells are stacked with spacers therebetween.

4. Apparatus as recited in claim 1, wherein the housing shells are stacked contiguously so that their inner surfaces form a hollow tube, and wherein a pump and piping system is provided for circulating the bath between the anode basket and the cathodic inner surfaces during the coating process.

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