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PROCESS OF ELECTRODEPOSITING AN ALLOY OF LEAD AND INDIUM

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This invention relates to the electro-deposition of metals. The particular object of the invention is to provide a method whereby a layer of a metallic alloy comprising lead and indium, with or without other constituents, can be deposited electrolytically to form the bearing metal layer of a bearing for internal combustion engines or other devices. The method of the invention may, however, be applied to the electro-deposition of other metals and metallic alloys and may be used for purposes other than the production of bearings.

The invention consists broadly in the use as the electrolyte or bath in the electrolytic process of a solution of the perchlorates of the metal or metals to be deposited. The electrolyte may consist of the perchlorates dissolved in water, but preferably these perchlorates are dissolved in an organic solvent to which, however, water may be added, in some circumstances.

Satisfactory results have been obtained by the use as the ionising solvent of a substantially anhydrous ether derivative of ethylene glycol of the type $R.O.(CH_2)_2.OH$ where R represents an alkyl group.

A solvent of this type with which we have obtained satisfactory results in practice is ethoxyethyl alcohol, which is available commercially under the name of ethyl "cellosolve." The same solvents may also be used with water present and, as before indicated, it may be desired in some cases to employ an electrolyte comprising the aqueous solutions of the respective perchlorates without the addition of organic solvents. When the aqueous electrolytes are employed, it is necessary to have some "free" perchloric acid present, at least sufficient to prevent precipitation of the metals to be deposited in the form of substantially insoluble compounds, and also to control anode dissolution. The anode should where possible be of such a composition as to maintain the correct concentrations of metals in the electrolyte appropriate to the composition of the alloy being deposited at the cathode. The use of substances known as inhibitors or addition agents is in some cases advantageous in bringing about a substantial improvement in the nature of the deposit.

In order that the invention and the manner in which it is performed may be more clearly understood details are given below of certain specific examples of methods in accordance with the invention. These examples are illustrative only and in no way limit the scope and application of the invention.

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Example I

Co-deposition of an alloy of lead and indium was effected from an aqueous bath having the following composition:

Lead, 1 gm./l. as perchlorate.
Indium, 21 gm./l. as perchlorate.
Added perchloric acid, 20 gm./l. added as 60% by weight aqueous solution.

The deposition was made at a cathode and anode current density of 7 to 10 amperes per square foot at room temperature and the deposit contained about 10% of lead by weight the remainder being about 90% indium. The deposit was light in colour and smooth.

Example II

Co-deposition of an alloy of lead and indium was effected from a non-aqueous bath of the following composition:

Lead, - gm./l. as perchlorate.
Indium, 20 gm./l. as perchlorate.
No added perchloric acid.
Ethoxyethyl alcohol as solvent.

Deposition was made at anode and cathode current densities of 7 to 10 amperes per square foot at a temperature of 60° C. The deposit was similar in nature to that obtained from the aqueous electrolyte of Example I, but contained a higher proportion of lead.

Example III

A bearing metal layer of lead indium alloy was applied to the cylindrical surface of a main shaft bearing, such as is used in aircraft internal combustion engines, in the following manner. The bearing consisting of a steel back with a lead bronze layer thereon, was machined to within the fine limits usually encountered in practice, cleaned, for example by degreasing in trichlorethylene vapour, and rinsed in ethyl "cellosolve." The deposition was carried out in an electrolyte of the composition indicated below with a bath temperature between 70 and 80° C., very slight

agitation being employed in order that no local heating of the solution should take place:

Indium, 20 gm./l., lead, 11 gm./l., as perchlorates in ethyl "cellosolve."
Colophony, 4 gm./l.

A cathode current density of 7 to 10 amps. per square foot was used. The deposit obtained was smooth in appearance and contained approximately 5% indium with the balance substantially lead. The bond between the deposit and the lead bronze layer was excellent and this is regarded as arising from the fact that the electrolyte acts as a cleaner. The anode employed consists of an 8% indium lead alloy and showed satisfactory dissolution. From the foregoing it will be seen that the indium lead alloy anode had a slightly higher percentage of indium than that present in the deposit. The cathode efficiency was of the order of 70%.

In effecting the co-deposition of lead indium alloys by the method illustrated by the foregoing examples, the composition of the deposit obtained is dependent upon a number of factors, including temperature, the degree of agitation used (increased agitation markedly increasing the lead concentration in the deposit) and the metal ion concentrations. The following table shows the approximate effect on the composition of the deposit of varying the lead concentration between 5 and 12 grams per liter in the solution used in Example III above, all other factors being as nearly as possible unchanged:

Pb concentration gm/l.	5	6	7	8	9	10	11	12
Per Cent indium in deposit	40	20	15	10	11	5	5	1

Owing to the difficulty of ensuring similar conditions in all tests, these figures should be regarded as showing only the general effect of varying the lead concentration and not as a precise guide to the lead concentration required to produce a deposit of given composition. We have found that a lead concentration of 1 to 12 grams per liter is satisfactory, and that the indium in the deposit may range between 1 to 90%. As shown by the table, the indium in the deposit may range from 1–40% when the lead concentration varies between 5 and 12 grams per liter.

The current efficiency of the process also appears to be dependent on a number of factors such as metal ion concentration, deposit composition, electrolyte temperature, acid concentration and current density, all of which need to be considered in practice. In general, our experience shows that the efficiency is higher in the non-aqueous solvents.

An increase in temperature results in an increase in the conductivity of the bath and if electrolysis is carried out at higher temperature it is desirable or necessary to decrease the voltage applied to the cell in order to maintain the current density in the range prescribed.

Another specific application of the invention is its use for effecting the electro-deposition of a ternary alloy comprising lead, tin and indium for the purpose of providing a bearing surface layer. The percentage composition of the material deposited will vary with the particular application of the bearing layer.

The specification of co-pending application for Letters Patent No. 708,190 filed November 6, 1946, by Guy Anthony Vandervell and Noel Percy Mallet, which has become abandoned, describes (inter alia) a bearing which comprises a steel back, an intermediate layer of lead bronze and a final bearing layer of lead, indium and tin. In such bearings it is inadvisable to have a final layer containing much tin, as thin tin is apt to diffuse thermally from the upper layer into the substrata.

On the other hand, when the bearing layer is deposited directly on to a steel back in the manner described in co-pending application for Letters Patent No. 669,448 of David Frederick Green, John Ernest Salmon and Noel Percy Mallet filed May 13, 1946, we prefer to deposit an alloy containing a substantially greater proportion of tin. Such higher tin content alloys may also be used in multi-ply bearings in cases where the thermal diffusion of tin into the bronze intermediate layer is not a prohibitive factor, for example, when lead is absent from the bronze.

Example IV

The following alloy was deposited directly on to a steel back from our electrolytic bath, the analysis being of a nominal nature as some impurities are inevitably present:

	Per cent
Lead	42
Tin	42
Indium	16

The electrolyte used in depositing this alloy was prepared from the perchlorates of lead, tin and indium dissolved in ethoxyethyl alcohol. The electrolyte was initially substantially anhydrous and had the following composition:

	Gm./l.
Lead	8
Tin	10
Indium	20
Colophony	4

The bath was operated at 70° C., without any agitation. Cathode current density=anode current density=10 amps. per square foot. Lead indium alloy anodes containing 10% by weight of indium were used. We have, however, found that by suitable adjustment of the anode composition a material comprising all three metals may be employed; for instance an anode containing 60% lead, 20% indium and 20% tin dissolves at the theoretical rate.

What we claim and desire to secure by Letters Patent is:

1. A process of electro-depositing an alloy of lead and indium which comprises the steps of preparing a non-aqueous solution of about 20 grams per liter of indium as perchlorate and 1 to 12 grams per liter of lead as perchlorate dissolved in ethoxyethyl alcohol, passing a current through the electrodes while maintaining the cathode current density at about 7 to 10 amperes per square foot, the alloy electro-deposited ranging from 90 to 1% indium and the balance lead, the anode containing an alloy of lead and indium with slightly higher percentage of indium than in the deposit and maintaining the bath temperature from 60 to 80° C.

2. A process of electro-depositing an alloy of lead and indium which comprises the steps of preparing a non-aqueous solution of about 20 grams per liter of indium as perchlorate and 5 to 12 grams per liter of lead as perchlorate dissolved in ethoxyethyl alcohol, passing a current

through the electrodes while maintaining the current density at about 7 to 10 ampres per square foot, the alloy electro-deposited ranging from 40 to 1% indium and the balance lead but in inverse proportion to the concentration of lead perchlorate, the anode containing an alloy of lead and indium with slightly higher percentage of indium than in the deposit and maintaining the bath temperature from 60 to 80° C.

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