Oct. 11, 1949. J. M. BOOE 2,484,068

ELECTRODEPOSITION APPARATUS

Original Filed March 11, 1943 2 Sheets-Sheet 1

Fig. 1

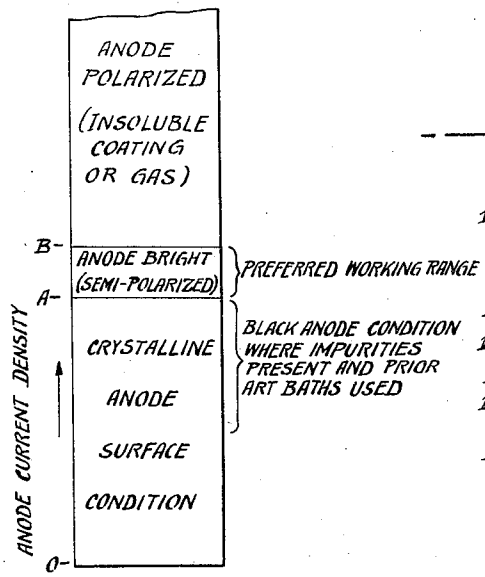
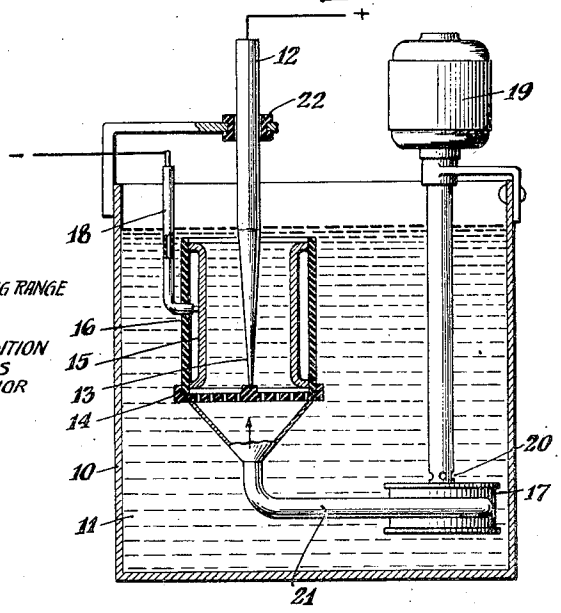


Fig. 2



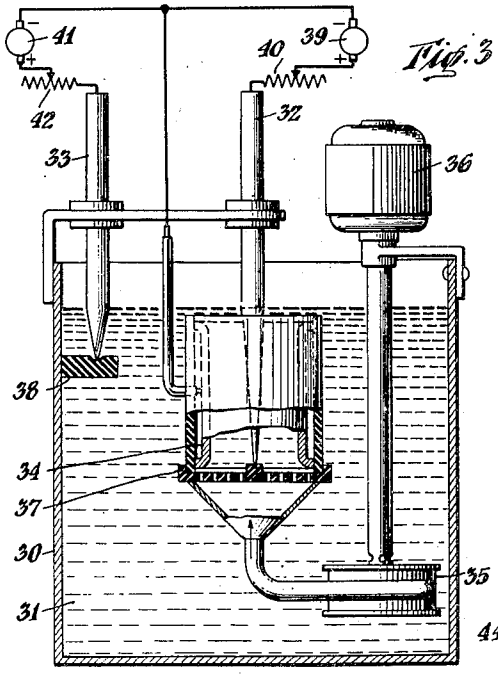
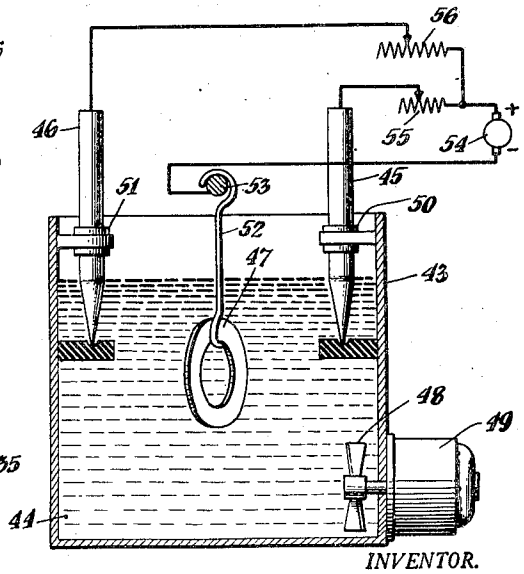


Fig. 3

Fig. 4



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Fig. 5

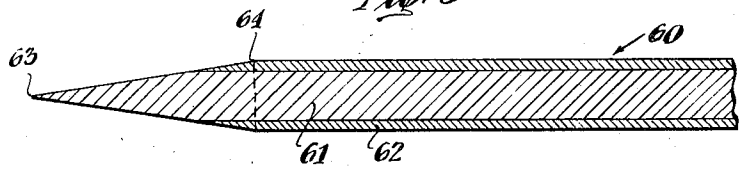


Fig. 6

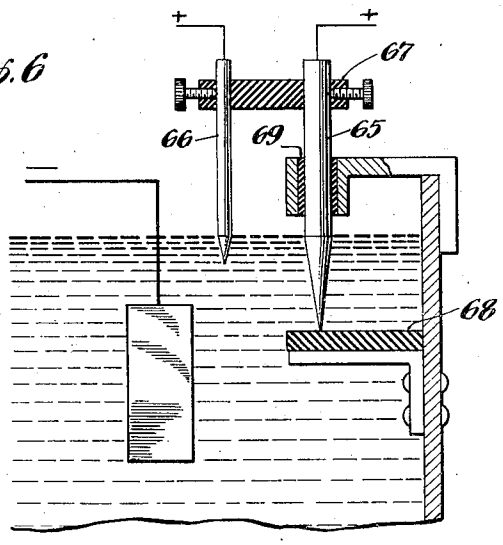
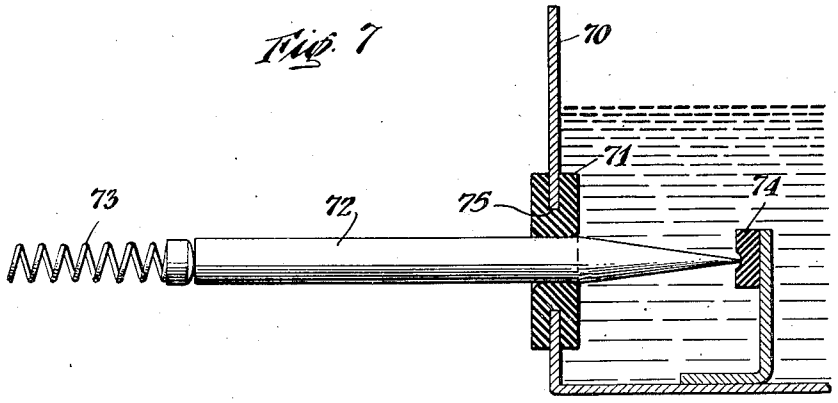


Fig. 7



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ELECTRODEPOSITION APPARATUS

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Original application March 11, 1943, Serial No. 478,750. Divided and this application March 10, 1944, Serial No. 525,907

6 Claims. (Cl. 204—225)

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This invention relates to apparatus for the electrodeposition of metals and alloys. This application is a division of my co-pending application S. N. 478,750 filed March 11, 1943.

An object of the invention is to improve electrodeposition apparatus.

Other objects of the invention will be apparent from the description and claims.

In the drawings:

Figure 1 is a diagram illustrating the preferred working range of anode current density for electrodeposition according to the present invention;

Figure 2 is an elevation with parts in vertical section showing a plating tank and apparatus for plating the inside of a cylinder;

Figure 3 is an elevation with parts in vertical section of electroplating apparatus showing the use of two anodes and two power sources for alloy plating;

Figure 4 is an elevation of a tank plating apparatus using a single power source;

Figure 5 is a longitudinal section of an anode for alloy plating;

Figure 6 is an elevation partly in section of part of an electroplating apparatus showing a modified anode feeding arrangement for alloy plating; and

Figure 7 is an elevation partly in section showing another anode feeding arrangement.

The present invention contemplates the use of tapered or pointed anodes and of improved mounting arrangements and means for introducing the anodes into the electrodeposition bath.

In the electrodeposition of metals and alloys I have found that the anode surface condition can be changed by increasing the anode current density. Various anode surface conditions are indicated in the diagram of Figure 1. With low anode current densities the anode takes on a crystalline, matte, or dull, appearance. Plating processes of the prior art operated the anodes in this range. This has resulted in metal particles falling into the solution. In this range, the current is roughly proportional to the applied voltage. The "black anode" condition, if present, occurs in this range.

As the voltage is increased, a point A is reached where the anode rather suddenly becomes smooth and bright and is no longer crystalline in appearance. This may be accompanied by fluctuating shadows playing over the anode surface. It is also accompanied by a sudden rise in voltage at the anode without a proportional rise in current. Further increase in voltage will not proportionally increase the current density. The anode may be said to be in a "semi-polarized" condition. Dissolution appears to take place uniformly over the anode surface.

The semi-polarized range has as its upper limit B the current density at which the anode becomes completely polarized as evidenced by formation of an insoluble dull coating on the anode surface or generation of gas.

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The type of behavior described above applies to the platable metals, generally, that is, to zinc and the metals below it in the electrochemical series, such as cadmium, iron, the tin group, lead, copper, silver, gold, the platinum group and others, as well as to alloy anodes. The current densities A and B, marking the limits of the semi-polarized range, depend upon the anode metal as well as upon the composition of the plating bath, the temperature and the rate of circulation or agitation of the bath.

I have found that by operating the anode in the semi-polarized range the plating difficulties associated with fine metal particles in the bath can be eliminated and other advantages attained as well. Not only are no particles of the anode metal released into the bath, but the impurities associated with "black anodes" do not form particles in the solution. In the bright range apparently the oxidizing potential is sufficient to dissolve the impurities along with the silver so that no precipitate forms at the anode.

With ordinary alkaline plating baths, the bright range A—B is narrow and occurs at a fairly low current density. The current density for the bright range can be increased and the bright range broadened by the addition of corrosive ions to the plating bath. These are ions which form highly soluble compounds with the anode metal and hence promote dissolution of the anode. For example, in the case of a lead anode tartrate and citrate ions produce this result and hence the addition of one of their compounds, such as potassium tartrate, is desirable. With silver anodes cyanide is a corrosive ion.

When operated in the bright range with corrosive ions present the anode operates at 100% current efficiency.

Increase in temperature of the plating bath and increased circulation or agitation also raise and broaden the bright range and so are also desirable for better regulations, higher plating speeds and greater efficiency.

In raising the anode current density the anode size is reduced for a given cathode area. It has been conventional in electroplating practice to provide an anode area at least equal to the cathode area and usually greater than the cathode area. This was done because with smaller anode areas, under usual plating conditions, gassing takes place at the anode, causing a depletion of metal in the bath, and in the case of cyanide baths, acceleration of the formation of carbonates. In the present invention the anode area is greatly reduced. In the case of lead anodes, for example, the anode area may be only 1/30 to 1/10 that of the cathode and the anode current density may be 30 to 50 amperes per square foot.

The small anode area also introduces mechanical advantages in plating certain shapes.

In summary, the following factors are combined to provide an electrodeposition process which prevents the introduction of metal particles into the solution, operates at greater plating speed and has 100% anode current efficiency;

1. Operation of anode in semi-polarized or bright range.

2. Use of corrosive ions in the plating bath. This is particularly applicable to alkaline baths.

3. Operation at high anode current density.

4. Anode area much smaller than cathode area.

The anode area in contact with the solution is small, and it must be kept within certain fairly close limits in order to preserve the semi-polarized condition and to regulate the cathode current density. I have devised an anode rod having a body portion of substantially uniform cross section and an end portion tapered to a point, which is allowed to rest on a support in the plating bath. If the semi-polarized condition is maintained along with fairly uniform agitation of the bath, the anode will dissolve uniformly and a sharply pointed condition is preserved and the anode settles so as to keep the same area always in the solution. This will be clearer from the more detailed description and the illustrations of the drawings.

Plating apparatus suitable for plating a single metal, such as lead, silver or copper is illustrated in Figure 2 of the drawing and comprises a tank **10** containing the plating bath **11**, the anode **12** which is tapered to a point **13** which rests on a perforated insulating plate **14**, the cathode **15** comprising a bearing sleeve resting on plate **14**, an insulating tubular mask **16** surrounding the exterior of the cathode, and a circulating pump **17**. A covered conductor **18** passes through mask **16** and connects the cathode to the negative terminal of a D. C. power source. The pump **17** is driven by electric motor **19** and draws in plating solution at **20** and forces it via pipe **21** through the holes in plate **14** and up through the center of the cathode bearing shell **15**.

The anode **12** comprises a rod of lead, silver, copper or other metal (preferably round) having a body portion of substantially uniform cross section which is tapered to a point **13** at its lower end. The taper is of such length as to provide the desired anode area in the tapered section. The support for the point **13** and the solution level are adjusted to bring the surface of the solution even with the upper end of the taper. The anode rod is supported loosely by an insulating sleeve **22** above the soltuion so that it may settle into the solution as the tapered portion is dissolved.

I have found that under these conditions, when the anode is operated in the bright or semi-polarized condition, and the circulation or agitation of the solution around the anode is fairly uniform, the current is uniformly distributed over the entire tapered area so that the tapered surface dissolves uniformly from the beginning of the taper to the tip, thus the same taper is always preserved as the anode rod settles into the solution and no particles or sections can become eaten away from the anode and drop off into the solution.

Figure 3 shows a suitable apparatus for silver-lead plating. It comprises plating tank **30** containing silver-lead bath **31**, silver anode **32**, lead anode **33**, cathode **34** and circulating pump **35** driven by motor **36**. Both the lead anode **33** and

the silver anode **32** have body portions of substantially uniform cross section and are tapered, the tapered surfaces being proportioned to the relative areas required. Silver anode **32** rests on perforated plate **37** so that its tapered portion is located along the axis of the cathode cylinder. The lead anode **33** rests on an insulating table **38** outside the cathode. The silver anode is connected to D. C. source **39** through current regulating resistance **40** and the lead anode is connected to D. C. source **41** through regulating resistance **42**. It is thus possible to adjust both anode currents independently.

Figure 4 shows a plating apparatus suitable for tank plating of miscellaneous parts. It comprises a tank **43** containing plating bath **44**, tapered anodes **45** and **46**, having body portions of substantially uniform cross section, and cathode **47**. The bath is agitated by a stirrer **48** driven by motor **49**.

The anodes rest their pointed tips or insulating supports below the solution level and slide into the solution through guiding sleeves **50** and **51** of insulating material. The cathode parts are suspended by hooks **52** from bus bar **53** connected to the negative terminal of a D. C. source **54**. The anodes **45** and **46** are connected to the positive terminal of the source through current regulating adjustable resistors **55** and **56** respectively. The current can thus be readily proportioned between the anodes.

The anodes may be of the same or different composition depending upon whether pure metal or an alloy is to be deposited, the plating bath being of suitable composition.

It is also contemplated that in the arrangements of Figures 2 and 4 the anodes can be formed of an alloy of the composition to be deposited. The oxidizing potential, when the anodes are operated in the bright range, is sufficient to dissolve both metals simultaneously.

Figure 5 shows in section a tapered anode, having a body portion of substantially uniform cross section, for alloy plating comprising a core **61** of a first metal and a coating **62** of the second metal to be deposited. For example, the core may be of silver and the coating of lead. The anode is supported from the silver tip **63** in the plating bath with the level of the bath at the upper end of the taper **64**. With corrosive ions for both metals in the solution, it is possible to operate the anode with both metals working in the bright range so that uniform dissolution takes place and the same taper is preserved as the anode settles into the bath. With a silver-lead anode there is some tendency of the lead to polarize due to the high current density but this can be overcome by using sufficiently high pH solutions. The thickness of the metal coating **62** is selected to give a relative cross-section of the two metals in the proportions desired in the electrodeposited alloy.

Figure 6 shows a modification in which the two tapered anodes **65** and **66**, having body portions of substantially uniform cross section, are clamped in an insulating yoke **67** at their upper ends and the point of anode **65** rests on table **68** under the solution and is guided by loose sleeve guide **69**. It will be apparent that dissolution of both anodes will take place at the same linear rate and hence the amount of the metals dissolved will be in proportion to their areas.

Figure 7 shows a method of introducing a tapered anode, having a body portion of substantially uniform cross section, below the surface of

the plating bath. The plating tank 70 is provided with a circular aperture 75, the edge of which is lined with a soft rubber or a synthetic elastomer, for example polymerized chloroprene ring 71 through which anode 72 is fed by a spring 73 or other feeding means. A stop 74 in the bath maintains the same tapered length in solution as the anode dissolves.

While specific embodiments of the invention have been described, it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. In an apparatus for the electrodeposition of metal from a bath, the combination which comprises an anode in the form of a rod composed of the metal to be deposited, said rod having a body portion of substantially uniform cross section and an end portion tapered to a point, means for slidably supporting the body portion of said rod, a supporting plate for the point of said rod, and means for urging the point of said rod against said plate, said supporting means and plate being so constructed and arranged as to expose solely the tapered end portion of the rod to contact with the bath.

2. In an apparatus for the electrodeposition of metal from a bath, the combination which comprises a cathode, an anode rod of the metal to be deposited having an elongated body portion of substantially uniform cross section and an end portion tapered to a point and in contact with the bath, the surface area of said tapered portion being the effective anode surface area and being only a small portion of the effective cathode area, a sleeve for holding the body portion of the rod for sliding axial displacement, a support in the bath, means for urging the point of the rod against said support, said urging means and said support cooperating to advance the rod into the bath at substantially the same rate as is dissolved and to retain a substantially uniform tapered shape having a substantially uniform surface area.

3. In an apparatus for the electrodeposition of metal from a bath, the combination which comprises a tank for the bath having an aperture in a wall thereof below the level of the bath, an anode rod having a body portion of substantially uniform cross section and an end portion tapered to a point extending through said aperture, a sealing sleeve in said aperture around said anode rod, a stop in said tank at the point of said rod, resilient means urging said point against said stop, and a cathode in said tank whereby, upon the application of a predetermined potential difference to said cathode and anode, metal will be deposited on the cathode and metal will be dissolved from the tapered portion of the anode rod and the said rod will be progressively fed into the bath at the same rate as it is consumed while retaining a tapered shape at its end.

4. In an apparatus for electroplating the inner surface of a cylinder, the combination which comprises an electroplating tank for holding a plating bath, means for supporting the cylinder to be plated in said tank with its axis vertical to and below the level of the bath, an elongated anode rod formed of the metal to be plated having a body portion of substantially uniform cross section and having one of its end portions tapered to a point, means for holding said rod for sliding displacement along the axis of said cylinder, and a support in said tank upon which the point of the anode rod rests with its tapered end portion in

contact with the bath said holding means and said support being so constructed and arranged that, upon the application of a predetermined potential difference between said cylinder and said rod, metal is deposited upon said cylinder and metal is dissolved from the tapered portion of said rod and the said rod is fed progressively by gravity into the bath at substantially the same rate as it is consumed while retaining its tapered shape at the end.

5. In an apparatus for the codeposition of metals from a plating bath, the combination which comprises a pair of anode rods formed respectively of the metals to be codeposited, each of said rods having an elongated body portion of substantially uniform cross section and an end portion tapered to a point, a stop in the bath against which the point of the first one of the rods may abut, continuously effecting feeding means for maintaining the point of said rod on said stop in such position as to expose solely the tapered end portion of the rod to contact with the bath, means securing the second of said rods in fixed parallel relation to said first rod with its tapered portion exposed to contact with the bath, and a cathode in the bath whereby, upon the application of a potential difference to said anode rods and cathode, an alloy will be deposited upon the cathode and metal will be dissolved from the tapered portion of both anode rods and the said rods will be progressively fed at the same linear rate into the bath while retaining a tapered shape at their ends.

6. In an apparatus for the electrodeposition of metal from a bath, the combination which comprises an anode rod composed of the metal to be deposited having a body portion of substantially uniform cross section and an end portion tapered to a point, means for holding the body portion of said rod for sliding displacement in generally perpendicular direction, and a supporting plate for the point of said rod against which said point is urged as a result of the action of gravity on the rod, said supporting means being so constructed and arranged as to expose solely the tapered end portion of the rod to contact with the bath.

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