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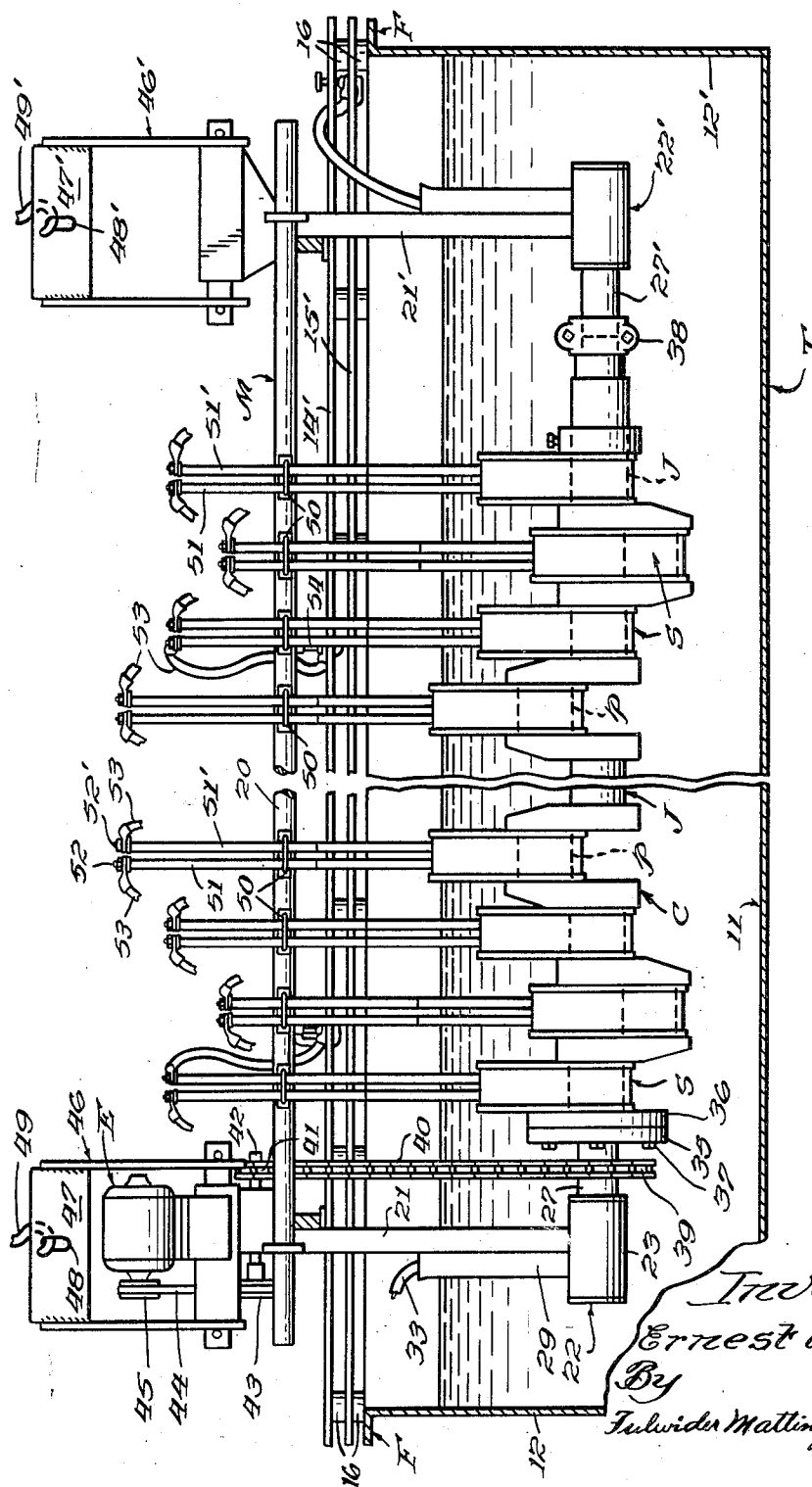
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ELECTROPLATING ANODE STRUCTURE

Filed June 29, 1953

3 Sheets-Sheet 1



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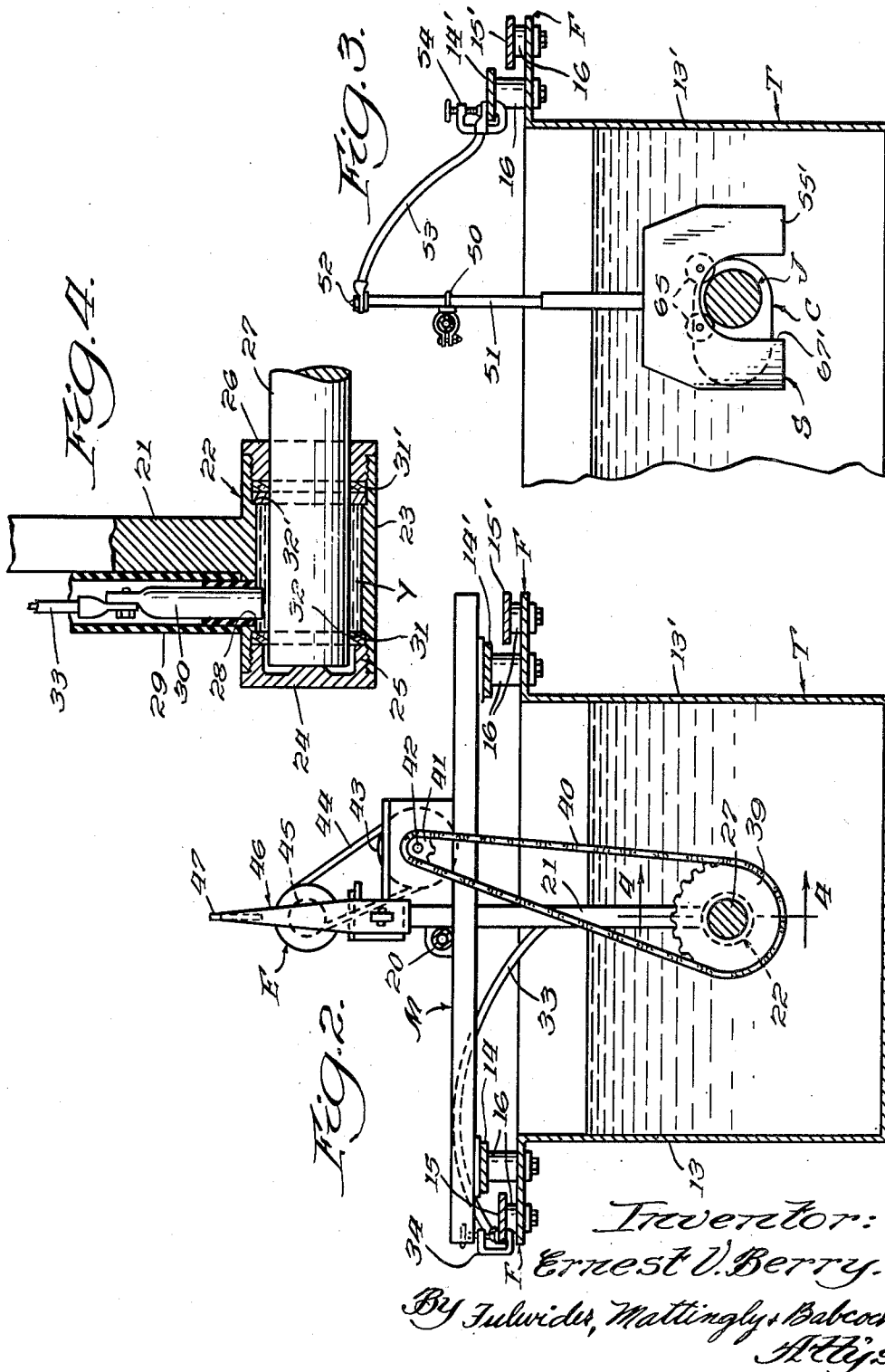
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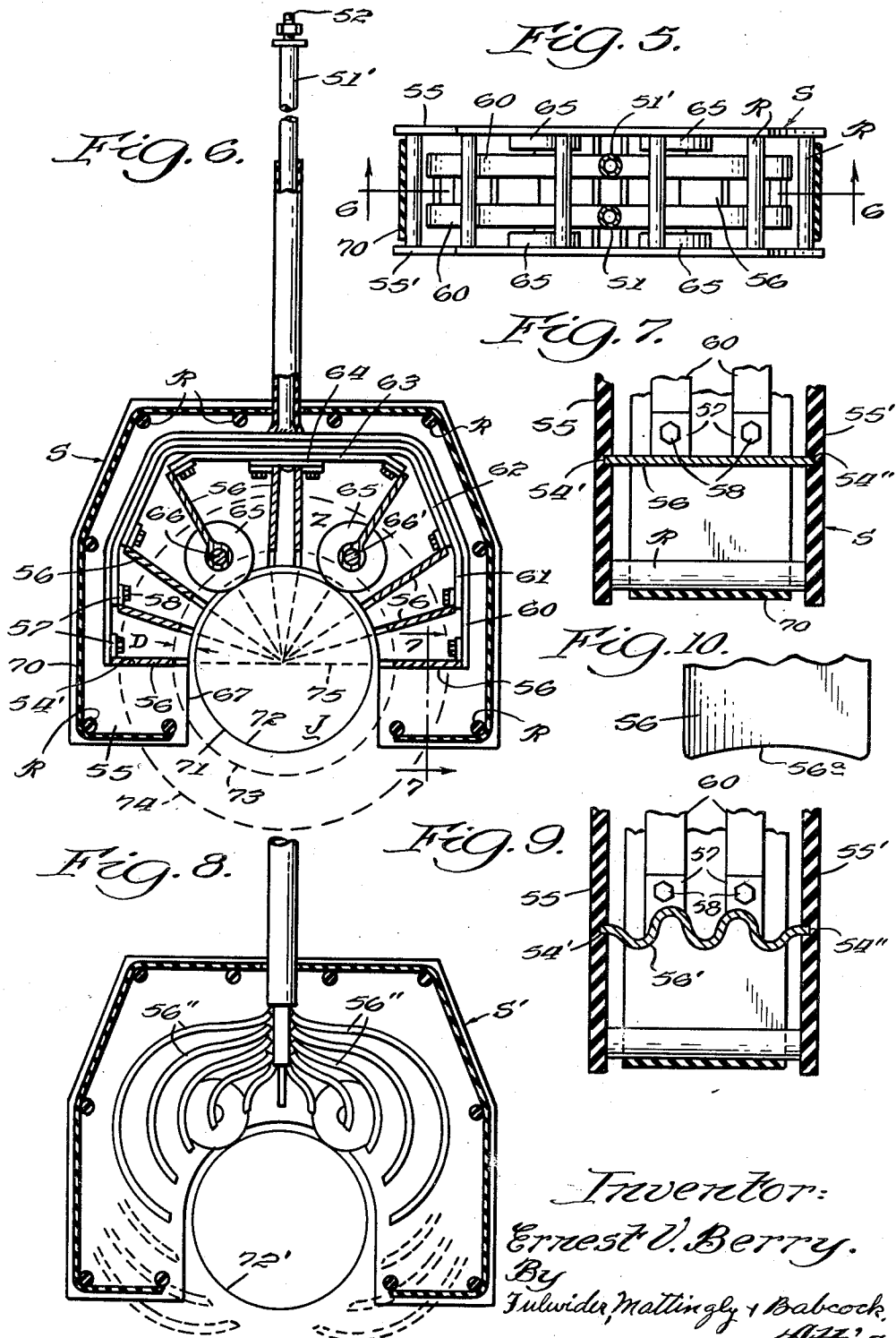
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ELECTROPLATING ANODE STRUCTURE

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9 Claims. (Cl. 204—212)

My invention relates to the field of electroplating, and more specifically to an anode structure and method of using same particularly effective in chromium plating crank pins and main journals of crankshafts, as well as other cylindrical surfaces such as calender rolls, and the like.

The previously available apparatus and methods for electroplating cylindrical surfaces with a layer of hard chromium have been found unsatisfactory in that it is extremely difficult to deposit a layer thereof of uniform thickness and proper homogeneous hardness, brightness and density. The difficulties encountered in obtaining the desired results with previously available apparatus and methods stem from the fact that the electro-chemical reactions involved in chromium electroplating are not clearly understood. As a result, improvements in both the apparatus and methods employed must be made from an empirical approach, rather than from a theoretical standpoint.

In contrast to plating with most other metals, commercial chromium electroplating is not carried out in a bath that is an aqueous solution of one of its salts, but instead an electrolyte is employed that is a water solution of chromic and sulphuric acids. In addition, an insoluble anode is utilized in this chromic acid bath.

The chromium in a chromic acid bath is initially in the hexavalent state, but has a tendency to be reduced to the trivalent state during the plating operation. It is most important to hold the trivalent chromium content of the plating bath to a minimum in order to attain chromium plating of uniform physical characteristics.

In the past, the chromium plating of main journal and crank pins of crankshafts has been accomplished by rotating the crankshaft in a chromic acid bath in which the crankshaft serves as a cathode. Arcuately-shaped anode plates are then disposed adjacent the cylindrical surfaces to be plated, with the cathode and anode connected to a suitable source of direct electrical power. From experience it has been found that this method of chromium plating is unsatisfactory as it is virtually impossible to deposit a chromium layer of uniform thickness on a cylindrical surface thereby.

By trial and error it has been found that the plating characteristics of a chromic acid bath are most sensitive to changes in the temperature thereof, the current densities on the anode and cathode, the pH of the bath, and the chromic and sulphuric acid content thereof. For instance, an increase in the concentration of chromic acid in the bath increases the conductivity thereof, but at the same time, decreases the cathode efficiency so that in many cases a higher current density does not increase the rate of chromium deposit. As another illustration of a change in the plating characteristics of a chromic acid bath, it has been found that an increase in current density at a given temperature causes the appearance, hardness and density of the deposited chromium to vary. In other words, the appearance of the deposited chromium may be caused to progress from (1) milky to (2) bright to

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(3) frosty, and finally to (4) burnt, by simply increasing the current density. However, an increase of current density on the anode increases the rate at which the objectionable trivalent chromium forms in the chromic acid bath. Therefore, it will be apparent that obtaining a hard, bright layer of electro-deposited chromium of uniform thickness on a cylindrical surface is a matter involving a number of variables which must be maintained in equilibrium to provide optimum plating conditions.

It will also be recognized that the variables influencing the physical characteristics of the deposited metal must be brought into equilibrium and so maintained without extensive manual supervision if consistent and uniform plating results are to be obtained. By means of the method and apparatus of my invention a heavy, elongate member such as a crankshaft may be easily raised from the floor, rotatably supported in a chromic acid bath, and as the crankshaft is rotated, the main journals and crank pins thereof are subjected to an equi-potential anode field whereby a uniform deposit of chromium of the desired brightness, hardness and density may be deposited thereon.

A major object of my invention is to supply a plating method and apparatus particularly adapted for chromium electroplating, embodying a structure in which a plurality of anode plates are radially disposed and circumferentially spaced relative to one another to provide an equi-potential plating field for a cylindrical surface as it rotates therethrough.

Another object of my invention is to provide an electroplating method and anode structure therefor that is at all times maintained at a fixed distance from the rotating cylindrical surface being plated, permits adjustment of the anode current density by the addition or subtraction of anode plates from said supporting structure, by means of which a layer of chromium or other metal of uniform thickness is deposited on cylindrical surfaces.

Yet another object of my invention is to provide an electroplating anode that permits the deposition of a hard, bright chromium plating on cylindrical surfaces without excessive formation of trivalent chromium occurring in the plating bath.

A still further object of my invention is to provide an electroplating method whereby a hard, bright chromium surface may be applied to a cylindrical surface as a layer of uniform thickness, at a maximum rate of speed without the occurrence of excessive trivalent chromium in the plating bath.

A further object of my invention is to provide an electroplating method and apparatus therefor which are simple in operation, readily adapted to pre-existing electroplating installations, may be operated by relatively inexperienced personnel, and assures the production of electroplated cylindrical surfaces of a uniform and quality standard.

These and other objects and advantages of my invention will become apparent from the following description of my plating method, and from the drawings illustrating an apparatus therefor in which:

Figure 1 is a cross-sectional view of a plating tank showing my vertically movable apparatus for rotatably supporting a crankshaft as the cathode mounted therein, and with the anodes of my invention operatively associated with the main journals and crank pins for the plating thereof;

Figure 2 is a combined vertical cross-sectional view of the plating tank and an end elevational view of the apparatus utilized in rotatably supporting a crankshaft;

Figure 3 is a fragmentary vertical cross-sectional view of the plating tank and a side elevational view of one of my anodes disposed therein;

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Figure 4 is a fragmentary vertical cross-sectional view of one of the rotatable supports for a crankshaft taken on line 4—4 of Figure 2;

Figure 5 is a plan view of one of the anode structures;

Figure 6 is a vertical cross-sectional view of an anode structure taken on line 6—6 of Figure 5;

Figure 7 is a fragmentary vertical cross-sectional view of an anode structure taken on line 7—7 of Figure 6;

Figure 8 is a vertical cross-sectional view of an anode structure, the plates of which are of an alternate construction;

Figure 9 is the same view as that of Figure 7, but showing an anode plate of alternate construction; and,

Figure 10 is a side elevational view of the lower edge of an anode plate.

The general arrangement of the apparatus used with my method of electroplating cylindrical surfaces may best be seen in Figures 1 to 6 inclusive. An elongate electroplating tank T is provided that has horizontal and outwardly disposed flanges F formed on the upper edges of the side walls thereof. The vertically adjustable mechanism M is adapted to rotatably support a crankshaft C in a substantially horizontal position within tank T, with the crankshaft being rotated by a motor E when so supported. A number of anode structures S rotatably engage the main journals J and crank pins P of the crankshaft when it is supported by the mechanism M. The detailed structure of the preferred form of my anode structure is best illustrated in Figures 5, 6, and 7.

Tank T is rectangularly-shaped, and from the bottom 11 thereof end pieces 12, 12' and side walls 13, 13' project upwardly to terminate in flanges F. Each flange F is affixed to side walls 13 and 13' supports two parallel, laterally spaced bus bars 14, 15 and 14', 15' respectively. Bus bars 14, 14' (see Figure 2) occupy inwardly disposed positions higher in elevation than bus bars 15, 15'. The bus bars 14, 15, 14' and 15' are supported from flange F by electrical insulators 16. Bars 14, 14' are connected to the positive terminal of a source of direct electrical power (not shown), and bars 15, 15' to the negative terminal of the same source of power. The bus bars 14, 14' serve to supply electrical energy to the anodes S as will hereinafter be explained in detail, and bars 15, 15' supply electrical energy to the crankshaft C, which serves as the cathode.

Crankshaft-supporting mechanism M best seen in Figures 1 and 2, includes an elongate, horizontally disposed rigid member 20. Two vertically disposed supports 21 and 21' depend downwardly from the end portions of member 20, said supports each having a combined bearing and rotary electrical contact 22 and 22' respectively, mounted on the lower ends thereof. Contacts 22 and 22' are of identical construction.

In Figure 4 one of the combined bearing and rotary electrical contacts is shown, and it will be seen to include a horizontally disposed cylindrical shell 23 rigidly affixed to the lower end of support 21. The end portions of shell 23 are tapped, with the outwardly disposed end of said shell having a plug 24 threaded therein. A bearing 25 is formed as a part of plug 24 situated within the confines of the shell 23. The inwardly disposed end of shell 23 has a threaded sleeve 26 mounted therein. The inwardly disposed end portion of a horizontal shaft 27 is rotatably supported in shell 23 by bearing 25 and sleeve 26.

Shell 23 has an opening 28 formed in the upper portion thereof communicating with a vertically positioned tube 29. Tube 29 permits the introduction of mercury Y into the confines of shell 23, and serves as a housing for an electrode 30 that contacts the mercury after it is so introduced. Escape of mercury Y from shell 23 is prevented by means of two annular resilient sealing gaskets 31 and 31' encircling shaft 27 which are compressed between body shoulders 32, 32' and the inwardly disposed

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ends of bearing 25 and sleeve 26 respectively. Electrode 30 has an insulated electrical conductor 33 extending therefrom to a clamp 34 that is removably affixed to one of the bus bars 15. The mercury Y disposed in shell 23 assures a good electrical connection between electrode 30 and shaft 27, irrespective of whether the shaft is stationary or rotating.

An annular flange 35 is mounted on shaft 27, which flange is a companion to flange 36, which is an integral part of the crankshaft C. The two flanges 35 and 36 are removably held together by bolts 37. The opposite end portion of crankshaft C and shaft 27' are removably connected to one another by a collar 38. Shaft 27 has a sprocket 39 mounted thereon that engages an endless chain belt 40, which belt extends upwardly for engagement with a sprocket 41 mounted on a jack shaft 42. Jack shaft 42 is provided with a pulley 43 driven by an endless belt 44 extending upwardly to a driving pulley 45 on motor E. Motor E and jack shaft 42 are supported on a rectangularly-shaped frame 46 rigidly connected to member 20. A similarly shaped frame 46' is provided on the opposite end portion of member 20. Frames 46, 46' are provided with heavy cross pieces 47, 47' respectively, which cross pieces have centrally disposed slots 48, 48' formed therein for engagement with hooks 49, 49' of chain falls (not shown) for the raising and lowering of crankshaft C relative to tank T.

Member 20, as may be seen in Figure 1, has a number of longitudinally spaced pairs of electrically insulated, vertically disposed eyes 50 mounted thereon, each pair of which slidably supports two parallel, laterally separated, electrical conducting tubular members 51, 51'. Each member 51, 51' has a terminal 52, 52' respectively, mounted on the upper end thereof, and insulated electrical conductors 53 extend from terminals 52, 52' to clamps 54 that may be removably affixed to one of the bus bars 14, 14'. Each pair of tubular members 51, 51' forms a part of one of the anodes S, the detailed structure of which may best be seen in Figures 6 and 7. The body of each anode is fabricated from two laterally separated sheets 55, 55' of an inverted U-shape. Sheets 55, 55' are held together as an integral unit by a number of rigid, transversely disposed rods R that engage the edge portions thereof. Sheets 55, 55' (Figure 6) have matched radially disposed slots 54', 54'' respectively, formed on the interior surfaces thereof. Each pair of slots 54', 54'' slidably receives an anode plate 56 of substantially rectangular shape in which two angularly disposed ears 57 are formed on the outwardly disposed edge portion thereof.

The ears 57, by bolts 58 or other means, are connected to a group of concentrically disposed, laterally separated pairs of inverted U-shaped electrical conductors 60, 61, and 62. Two pairs of horizontally disposed conductors 63, 64 are provided that are substantially straight. Each set of conductors 60, 61, 62, 63 and 64 are preferably electrically insulated from one another to assure that each anode plate 56 is at the same electrical potential.

Four rollers 65 (Figures 5 and 6) formed of a resilient electrical insulating material are rotatably supported in pairs on two horizontally disposed shafts 66, 66' extending between the sheets 55, 55'. Rollers 65 are positioned in the upper portion of the centrally disposed openings 67, 67' of sheets 55, 55'. The rollers 65 are adapted to rotatably engage one of the crank pins P or main journals J of the crankshaft C to support the anode S thereon. In Figure 6 it will be seen that a strip of sheet plastic 70 or other electrical insulating material extends around the outer edge portions of the sheets 55, 55'.

When the anode structure S is supported by rollers 65 above a cylindrical surface such as a main journal J, the inwardly disposed ends of all the anode plates 56 are maintained a predetermined distance from the surface being plated. This predetermined distance D holds constant, even as the thickness of the deposited metal increases, for the reference plane on which the rollers 65

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travel is the surface of the deposited film. The predetermined distance D (Figure 6) is that space between the exterior surface 71 of the layer of deposited metal 72, and the circle 73 shown in phantom line touching the lower edges of anode plates 56.

Anode plates 56 are equally spaced and radially disposed relative to one another. The circle 74 also shown in phantom line in Figure 6, defines the outer boundary of an equi-potential zone Z wherein each anode plate 56 has the same effective area and is at the same potential to cause the deposition of a layer of chromium on a cylindrical surface. The lower boundary of the equi-potential zone is substantially defined by the horizontally disposed phantom line 75. The portions of the anode plates 56 and the conductors 60, 61, 62, 63 and 64 outside the equi-potential zone Z may be masked with a coating of electrical insulating material to prevent a distorting effect on the zone thereby.

In the operation of my apparatus and method it is occasionally found that the center of the cylindrical surface being plated tends to receive a metal coating thereon at a more rapid rate than the balance of the surface. This situation is easily corrected by giving the lower edge 56a of each anode plate 56 a concave curve (see Figure 10). The degree of concave curvature must be empirically determined by actual plating tests, and once determined, no further experimental work will be required so long as the same physical variables of the plating bath prevail.

In the event it is desired to increase the effective area of the anode plates 56 within the equipotential zone Z, the plates may be changed to the alternate corrugated construction shown in Figure 9. This corrugated anode plate construction is identified in the drawings by the numeral 56'.

An alternate form of anode structure S' is shown in Figure 8, which is essentially identical to my preferred form with the exception that the anode plates 56'' thereof are elongate strips bent into the curved configurations shown in this figure. The ends of the anode plates 56'' are all equi-distant from the cylindrical surface 72' being plated. If desired, the additional elongate anode plates 56'' shown in phantom line may be added to completely encircle the cylindrical surface.

The application of my invention is extremely simple. Mechanism M, inasmuch as it is supported from chain falls, may be easily lowered into or raised from the electroplating tank T. This particular mode of supporting mechanism M is of a distinct advantage, as it permits free use thereof with any one of a number of electroplating tanks. The structure of mechanism M provides a further advantage in that the supports 21, 21' and the frames 46, 46' associated therewith may be longitudinally adjusted on member 20 by use of suitable locking means, not shown. Thus by longitudinal adjustment of supports 21 and 21', the mechanism may be adapted to rotatably support crankshafts C of various lengths.

After a crankshaft C is rotatably supported by the mechanism M, the anode structures S are mounted on the mechanism in the positions shown in Figure 1. Motor E is then actuated, causing crankshaft C to rotate at a uniform rate of speed. The electrical circuit used in the plating operation is completed when electrical current is supplied to the crankshaft C serving as the cathode through the rotary mercury contact (Figure 4). As the crankshaft C is rotated, those anodes S resting on the crank pins P will reciprocate up and down as they follow the circular path of the pins, with the tubular members 51, 51' being slidably guided by the eyes 50. Those anodes S resting on the main journals J will, of course, not be subjected to reciprocatory motion.

As a cylindrical surface 71 rotates, it continues to pass through the equi-potential zone Z (Figure 6) wherein it is subjected to a continuous and uniform electro-chemical action whereby a metal coating is deposited thereon. By use of my anode structure, it is possible to employ

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any desired number of anode plates, as well as any desired size thereof in order to establish the zone Z at the proper electrical potential and secure optimum plating results. Furthermore, the anode plates 56, 56', and 56'' may be easily removed from or inserted between plates 52 whenever necessary.

It has been found that my plating apparatus and method will operate in a consistent and uniform manner after extensive use and provide results of a much higher quality than heretofore available.

Although my invention is fully capable of achieving the results and providing the advantages hereinbefore mentioned, it is to be understood that it is merely the presently preferred embodiment thereof and that I do not mean to be limited to the details of construction or the method steps above described other than as defined in the appended claims.

I claim:

1. An anode structure for chromium electroplating a cylindrical cathode surface of a crank pin as it rotates in a circular path in a vertical plane, which includes: two laterally spaced inverted substantially U-shaped sheets fabricated from an electrical insulating acid-resistant material, which sheets are formed with horizontal lower edges on which said anode may be supported in an upright position when not in use; means for maintaining said sheets including the lower portions thereof in a predetermined laterally spaced relationship; a plurality of circumferentially spaced, transversely disposed shafts extending between said sheets; a plurality of rollers mounted on said shafts, said rollers adapted to rotatably contact said cylindrical surface and maintain said sheets at a fixed predetermined distance therefrom; a plurality of anode plates; electrical insulating means separating said plates; means for removably supporting said plates in fixed, circumferentially spaced, radially disposed positions between said side walls in sufficient quantity as to provide a desired area ratio between said anode and said surface; and electrical power supply means that supply substantially the same potential for each of said anode plates.

2. An anode structure capable of supporting a plurality of anode plates to obtain a desired cathode current density in the chromium electroplating of a cylindrical surface as it rotates in a circular path in a vertical plane, which includes: two laterally separated sheets having a substantially inverted U-shape that may partially encircle said surface, said sheets being formed of a rigid, acid-resistant, electrical insulating material having a plurality of complementary slots formed in the interior surfaces thereof, which slots are in circumferentially spaced and radially disposed relationship, the flat lower edges of which sheets are normal to the sides thereof; means for holding said sheets in a fixed laterally spaced relationship with one another; a plurality of anode plates formed with two parallel longitudinally extending edges, said plates being of such width as to be slidably and removably supported in two of said complementary slots, the number of said plates being that required to provide the desired cathode current density when said anode plates are supplied with a predetermined quantity of electrical power; a plurality of electrical conductors that supply said electrical power to said plates when supported between said sheets; means to support said sheets on the upper portion of said cathode surface as it rotates, and maintain them at a fixed distance therefrom; and an elongate tubular member extending upwardly from said sheets and rigidly connected thereto, said member serving as a housing through which insulated electrical conducting leads may be extended to said conductors, which tubular member acts as a guide in regulating the positions of said sheets during rotation of said cylindrical surface, said member also serving as a handle for moving said anode structure when placing said sheets upon the supporting surface of said structure in an upright position to rest on said lower flat edges thereof.

3. An anode structure for chromium electroplating a rotating cylindrical surface, as it rotates about a substantially horizontal axis, at a desired cathode current density, which includes: two laterally separated sheets having a substantially inverted U-shape that may partially encircle said surface, which sheets are formed of an acid-resistant, electrical insulating material having flat lower edges on which said anode may be supported in an upright position when not in use; means for maintaining said sheets including the lower portions thereof in a fixed laterally spaced relationship; means for removably supporting a plurality of spaced, radially disposed anode plates between said sheets; a plurality of anode plates held in said supporting means, with the number of said plates so held being that required to supply said current density; roller means rotatably supported between said sheets that movably engage said surface being plated to support said anode structure thereon and maintain the inwardly disposed ends of said anode plates at a predetermined distance therefrom during the plating operation; and means to supply electrical energy to said anode plates.

4. An anode structure for chromium electroplating a cylindrical surface as it revolves in a circular path in a vertical plane at a desired cathode current density, which includes: two laterally separated sheets having a substantially inverted U-shape that may partially encircle said surface, which sheets are formed of an acid-resistant, electrical insulating material; means for maintaining said sheets in a fixed laterally spaced relationship; means for removably supporting a plurality of spaced, radially disposed anode plates between said sheets; a plurality of anode plates held in said supporting means; means mounted on said sheets that movably engage said cathode surface to support said anode structure therefrom and maintain the inner ends of said anode plates at a predetermined distance from the cathode-plated surface; and means to supply electrical energy to said anode plates.

5. An anode structure for chromium electroplating a circumferentially extending section of specific width on a cylindrical cathode surface as it rotates about a substantially horizontal axis in a plating bath, including: a plurality of rigid anode plates of substantially the width of said section, with the surface area of said plates being greater than that of said cathode surface so that no sub-

stantial quantity of trivalent chromium forms in said bath during the plating operation, which plates are circumferentially spaced from one another and have portions thereof adjacent said cathode surface which are substantially radially disposed relative to said cathode surface; rigid electrical conducting means affixed to said plates, which means maintains said plates in said spaced relationship; an assembly comprising vertically disposed spaced end sheets formed of an electrical insulating material positioned adjacent the ends of said plates, said sheets having recesses formed therein that partially encircle said surface, with the edges of said sheets, defining said recesses, located closely adjacent to said cathode surface so that only said section of specific width is plated; and means for supporting said plates, conducting means and end sheets at a fixed distance from said cathode surface as said surface rotates.

6. An anode structure as defined in claim 5 in which at least a portion of said anode plates are other than flat in shape so that the surface of said plates exposed to said bath is increased.

7. An anode structure as defined in claim 5 in which at least a portion of said anode plates are so formed as to define a corrugated transverse cross section to increase the surface area of said plates exposed to said bath.

8. An anode structure as defined in claim 5 in which the ends of said anode plates adjacent said cathode surface are concave so that a chromium layer of uniform thickness is deposited on said cathode surface.

9. An anode structure as defined in claim 5 in which said supporting means are rollers that rest on said cathode surface.

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