APPARATUS FOR PRODUCING SHEET METAL
BY ELECTRODEPOSITION

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Application May 14, 1956, Serial No. 584,716

5 Claims. (Cl. 204—208)

This invention relates to producing sheet metal by
electrodeposition on a rotating drum cathode, and then
stripping the electrodeposited cathode from the drum. The inven-
tion is particularly directed to the provision of an im-
proved method of carrying out the electrodeposition operation so as to produce an electrodeposited sheet of
improved surface quality and of improved uniformity of
gage across the width of the cathode drum on which it
is formed. The invention also provides improvements in
the apparatus used for producing electrodeposited sheet
metal in accordance with the new method.

Numerous proposals have been made heretofore for
producing a variety of metals in sheet form by electro-
deposition on a rotating drum cathode, and sheet copper
has been thus produced on a commercial scale for many
years. The electrodeposition method has the advantage
that sheets of wide width, thin gage, and indefinitely long
lengths can be produced. Sheet metal made in this
manner, however, is subject to considerable variation in
thickness across the width of the sheet; and it is difficult
to produce metal of very thin gage (weighing, say, one
ounce or less per square foot, in the case of copper)
that is free from pinholes. Heretofore the only way by
which it has been possible to produce electrodeposited
sheet copper having sufficient uniformity of gage and
freedom from pinholes, in thicknesses corresponding to
weights of one ounce to two ounces per square foot, has
been to subject the electrolyte between the cathode drum
and the nearby anode to intense air agitation.

While air agitation has been necessary to produce
electrodeposited sheet copper of acceptable quality, such
agitation is by no means free from objection. It causes
much splashing of the electrolyte, with the result that
the atmosphere in the vicinity of the electrodeposition
equipment becomes charged with an irritating acid mist.
Workmen in the area must wear some form of respiratory
protective apparatus, and the acid mist promotes discol-
oration and even damaging corrosion to the electrode-
posited sheet. Splashing and sloshing of the electrolyte
near the cathode drum also results in wetting and trap-
ping of specks of lead dust (from a polishing apparatus) on the surface of the cathode drum,
leading to a defect in the deposited sheet metal known as “leaded porosity.” And of course the splashing of
electrolyte and the acid mist in the vicinity of the electro-
deposition equipment promotes rapid corrosion of the
apparatus.

In accordance with the method of this invention it is
possible to eliminate air agitation of the electrolyte, and
all its attending disadvantages, and at the same time to
produce electrodeposited sheet metal of notably better
uniformity of gage thickness than can be produced with
air agitation, by forcibly projecting a turbulent stream of
electrolyte into the space between the cathode drum
and the adjacent anode, across substantially the entire
width of the drum. The stream of electrolyte overflows
from the space between cathode and anode without
splashing or producing any mist of acid electrolyte drop-
lets. Yet a cathode deposit of remarkable uniformity is
produced, which when stripped from the cathode drum
forms a sheet of notable uniformity of gage across its
width and freedom from objectionable pinholes and
other defects.

Preferably the stream of electrolyte is delivered sub-
stantially continuously into the space between the cathode
drum and the anode, and is introduced into that space
adjacent the line of deepest of the cathode drum in the electrolyte. The stream then is projected
upwardly in turbulent flow along the surface of each of
the two lower quadrants of the drum. Preferably the
stream of electrolyte flowing turbulent through the
space between cathode drum and anode is maintained
substantially free of gas bubbles (especially air or other
gas purposely introduced) in order to eliminate the
greatest possible extent the risk of introducing any acid
mist into the atmosphere. However, a small amount of
air or other gas may be utilized to promote agitation of
the electrolyte without sacrificing altogether the improved
quality of the electrodeposited sheet that is attained
in accordance with the invention.

The apparatus of the invention comprises a cathode
drum mounted for rotation on a horizontal axis, a

cylindrically curved anode mounted in closely spaced
relation with the cathode drum, and means for project-
ing a turbulent flow of electrolyte into the space between
anode and cathode. These means comprise a discharge
manifold which extends along an edge of the anode.
The discharge manifold comprises an elongated tubular
member divided longitudinally into a distribution com-
partment and a discharge compartment communicating
therewith. Means are provided for delivering electrolyte
solution into the distribution compartment, and the dis-
charge compartment is provided with a series of spaced
solution outlets along substantially the entire length of
the discharge manifold. Thus a stream of electrolyte
delivered under pressure into said distribution compart-
ment is projected substantially uniformly through said
outlets into the space between anode and cathode.

Generally the apparatus comprises a pair of cylindri-
cally curved anodes each mounted in closely spaced rela-
tion with one of the lower quadrants of the cathode

drum, and with the adjacent edges of the anodes spaced
apart substantially along the lowermost portion of the

cathode drum. In such apparatus the discharge manifold
is preferably positioned between the spaced adjacent edges
of the anodes.

A preferred embodiment of the method and apparatus
of the invention is described below with reference to
the accompanying drawings. While the invention is applica-
ble generally to all metals that can be electrodeposited
in sheet form, both the new method and the new appa-
ratus are especially suitable for use in conjunction with
the production of sheet copper by electrodeposition from
an acidic aqueous copper-bearing electrolyte. Accord-
ingly the following description refers particularly to the
production of electrodeposited sheet copper. In the
drawings,

Fig. 1 is an elevation, partly in section, through an

apparatus for producing sheet copper by electrodepo-

sition on a rotating drum cathode;

Fig. 2 is an elevation, partly in section and on an
e
dlarge scale, of the discharge manifold by which electro-
yte is projected forcibly into the space between anode
and cathode in the apparatus shown in Fig. 1; and

Fig. 3 is a cross section of the discharge mani-

dfold taken substantially along the line 3—3 of Fig. 2.

The apparatus shown in Fig. 1 comprises a tank of

concrete or other material which is provided interiory
A cylindrical cathode drum 16 of lead is supported by an axial shaft 17 which extends through bearings 18 mounted on the sides of the tank 10. The drum is slowly rotated in the direction indicated by the arrows by means of a sprocket chain 19 engaging sprocket wheels 20 and 21 mounted respectively on the drum shaft 17 and on a drive shaft 22. The drive shaft is continuously rotated by a motor (not shown).

A cylindrical cathode drum 16 of lead is supported by an axial shaft 17 which extends through bearings 18 mounted on the sides of the tank 10. The drum is slowly rotated in the direction indicated by the arrows by means of a sprocket chain 19 engaging sprocket wheels 20 and 21 mounted respectively on the drum shaft 17 and on a drive shaft 22. The drive shaft is continuously rotated by a motor (not shown).

The cathode drum 16 extends about half into and half out of the tank 10. A pair of cylindrically curved lead anodes 23 and 24 are mounted in the tank, in close proximity to the two lower quadrants of the cylindrical face of the cathode. Only narrow annular electrolyte spaces 25 and 26 are left between the anodes and the adjacent face of the cathode. The heavy anodes are supported in place by vertical support plates 27 mounted on brick piers 28. Electrical connections to the anodes are made through bus bars 29.

When a direct electric current is passed (at sufficient voltage) from the anodes 23, 24 through copper-bearing electrolyte in the electrolyte spaces 25, 26 to the cathode drum 16, copper is electrodeposited on the cylindrical face of the drum. As the drum rotates, this deposit is carried to above the surface of the electrolyte in the tank 10. There it is separated as a sheet 30 from the face of the drum by passing it over a stripping roll 31, and it is then wound into a coil 32 on a coil core 33. The coil core is mounted on a shaft 34 which is continuously driven by a sprocket chain 35 from the drive shaft 22, in order to maintain the copper sheet 30 under tension as it is stripped from the cathode.

In accordance with the invention, a discharge manifold 36 is mounted between the spaced adjacent lower edges of the anodes 23 and 24, where it extends parallel to the surface of the cathode drum adjacent the line of deepest immersion thereof. The discharge manifold is supported in place by means of a pair of end brackets 37 (only one of which is shown in Fig. 1) and one or more center brackets 38.

The construction of the discharge manifold 36 is shown in detail and on an enlarged scale in Figs. 2 and 3. It comprises lower and upper semi-cylindrical members 39 and 40 (formed, for example, by splitting a lead pipe longitudinally into two equal parts) joined together with a longitudinal partition 41 therebetween and closed at their ends. A solution distribution compartment 42 is defined between the lower member 39 and the partition 41, and a solution discharge compartment 43 is defined between the upper member 40 and the partition 41. The discharge compartment is preferably divided into a plurality of sub-compartments 44 by a series of transverse partitions 45. A solution inlet conduit 46 is provided for admitting electrolyte to the distribution compartment 42. Preferably, as shown, the inlet conduit 46 joins the discharge manifold about at the center thereof; but it can be connected at some other point if design of the apparatus so requires. Each discharge sub-compartment 44 is in communication with the distribution compartment 42 through an opening 47 formed in the longitudinal partition 41. These openings 47 are preferably of progressively larger size as they become more remote from the inlet conduit, thereby to insure substantially uniform distribution of solution to each of the discharge sub-compartments 44. At least one and preferably two rows of closely spaced solution outlet openings 48 are formed in the upper member 40 defining the solution discharge compartment. Thus, when solution is delivered to the discharge manifold through the inlet conduit 46, it is uniformly distributed through the distribution compartment to each discharge sub-compartment and therefrom is projected through the discharge openings 48.

As indicated in Fig. 1, the discharge manifold is mounted so that the streams of solution projected from the discharge openings 48 are delivered into the narrow electrolyte spaces 25 and 26 between the anodes and the cathode face of drum 16. The solution inlet conduit 46 is connected to a valve-supply pipe 49 through which electrolyte solution under pressure is delivered to the apparatus.

In operation of the above-described apparatus, the tank 10 is filled with a suitable electrolyte, e.g. an acidic aqueous solution of copper sulfate. A source of direct current is connected to the cathode drum 16 and to the anodes 23 and 24. The drive shaft 22 is set in operation, whereby the drum 16 is slowly rotated (in a counterclockwise direction as viewed in Fig. 1). The voltage between anodes and cathode is high enough so that copper is electrodeposited from the electrolyte in the spaces 25 and 26 between anode and cathode face to the surface of the cathode drum. As the drum rotates, this electrodeposited copper is carried to above the surface of the electrolyte in the tank. Conventionally, the deposit on the drum is carefully washed to remove residual electrolyte (by washing means not shown in the drawings). The electrodeposited copper is then stripped from the face of the drum in the form of the copper sheet 30 as it is stripped from the cathode.

The face of the drum from which the copper sheet 30 has been stripped passes under a polishing roll 50 which is continuously rotated at relatively high peripheral speed by a drive chain 51 which connects it to a continuously driven high speed polishing drive shaft 52. The polishing roll 50 rides along the smooth surface on the cathode drum to insure the formation of a cathode deposit of good quality and to insure ease of stripping of the deposit from the cathode.

In accordance with the method of the invention, electrolyte solution is introduced continuously and under pressure from the supply pipe 49 through the inlet conduit 46 to the discharge manifold 36. This electrolyte, which enters the distribution compartment 42 and is distributed thereby to the several discharge sub-compartments 44, is forcibly projected as a series of high velocity streams through the discharge outlets 48 into the electrolyte spaces 25 and 26. The electrolyte of these streams, together with electrolyte present in the tank and which is set into circulation by the force of the streams, flows upward through the electrolyte spaces toward the surface of the electrolyte at each side of the drum. Thus the electrolyte between the anodes and the cathode is continuously maintained in fast flowing turbulent motion and is continuously renewed and replenished.

The electrodeposited film of copper formed on the cathode drum surface while carrying out the method of this invention is of exceptional uniformity. Its gage thickness across the entire width of the drum is subject to but slight variation, and it is remarkably free of pin-holes and other porosity even when stripped from the drum in sheets of extreme thinness (e.g. one ounce in weight per square foot of surface area, which in the case of copper corresponds to an average gage thickness of only a little over 0.001 inch).

Hereofor it has been common practice to inject air into the electrolyte spaces 25 and 26 between the drum face and the anodes, thereby to promote agitation of the electrolyte adjacent the face of the drum. When employing the method of the present invention, no such air injection is necessary, and in fact it is preferable that the streams of liquid electrolyte projected through the discharge outlets of the manifold 36 be free of any intentionally injected air or other gas. The resulting freedom of the electrolyte from the effects of air agitation results in many improved operating conditions. In particular, the amount of acid electrolyte mist carried into the at-
5 atmosphere is very greatly reduced, with the result that working conditions in the vicinity of the apparatus are greatly improved, the discoloring effect of such mist on the electrolyte and electrodedeposited sheet is eliminated, and the corrosive effect of the atmosphere on machine parts is greatly reduced. Also, the splashing and sloshing of electrolyte at its surface level in the tank is eliminated with a number of consequent advantages. Notable among these is the substantial elimination of splashing of the electrolyte on to the surface of the cathode, in the vicinity of the polishing roll 50, which invariably results in occasionally entrapping specks of lead dust generated by the polishing roll 50 and causes them to adhere to the surface of the cathode drum. These specks are then carried on the drum surface to beneath the surface of the electrolyte where they give rise to the defect of "leaded porosity" in the cathode deposit formed on the drum. The elimination of splashing of the electrolyte also greatly reduces the maintenance work required on account of corrosion of machine parts that are necessarily located close to the electrolyte surface.

It is thus apparent that the method and apparatus of this invention make it possible to produce electrodedeposited sheet metal of significantly improved quality, and at the same time to greatly improve the operating conditions and to reduce the maintenance work incident to such production.

Claim:
1. Apparatus for producing sheet metal by electrodeposition from an electrolyte solution, comprising a cathode drum mounted for rotation on a horizontal axis, a cylindrically curved anode mounted in closely spaced relation with the cathode drum, and means for projecting a flow of electrolyte into the space between anode and cathode comprising a discharge manifold extending along an edge of the anode, said discharge manifold comprising an elongated tubular member divided longitudinally into a distribution compartment and a discharge compartment communicating with said distribution compartment, means for delivering electrolyte solution into the distribution compartment of said discharge manifold, and said discharge compartment being provided with a series of spaced solution outlets along substantially the entire length of the discharge manifold, said outlets being so positioned as to project a stream of electrolyte delivered under pressure into said distribution compartment into the space between the anode and the cathode drum to cause the electrolyte to flow along the surface of the cathode drum opposite said anode.

2. Apparatus for producing sheet metal by electrodeposition from an electrolyte solution comprising a cathode drum mounted for rotation on a horizontal axis, a pair of cylindrically curved anodes each mounted in closely spaced relation with one of the lower quadrants of the cathode drum, the adjacent edges of said anodes being spaced apart substantially along the lowermost portion of the cathode drum, and means for projecting a flow of electrolyte into the space between anode and cathode comprising a discharge manifold positioned between the spaced adjacent edges of the anodes, said discharge manifold comprising an elongated tubular member divided longitudinally into a distribution compartment and a discharge compartment communicating with said distribution compartment, means for delivering electrolyte solution into the distribution compartment of said discharge manifold, and said discharge compartment being provided with a series of spaced solution outlets along substantially the entire length of the discharge manifold, said outlets being positioned so as to project a stream of electrolyte delivered under pressure into said distribution compartment into the space between the anode and the cathode drum to cause the electrolyte to flow along the surface of the cathode drum opposite said anode.

3. In apparatus for producing sheet metal by electrodeposition, a discharge manifold comprising an elongated tubular member divided longitudinally into a distribution compartment and a discharge compartment, said compartments being in communication with each other at intervals along the length of the manifold, means for delivering electrolyte solution under pressure into said distribution compartment, and said manifold being formed with a row of closely spaced solution outlets along substantially the entire length of the discharge manifold, whereby a stream of electrolyte solution delivered into the distribution compartment is distributed thereby to the discharge compartment along the length thereof and is projected with substantially uniform force through each of said outlets.

4. In apparatus for producing sheet metal by electrodeposition, a discharge manifold comprising an elongated tubular member divided by a longitudinal partition into a distribution compartment and a discharge compartment, inlet means for introducing electrolyte solution under pressure into said distribution compartment, said partition being formed with a spaced series of openings providing communication between the distribution and discharge compartments, said openings being of progressively larger size as they become more remote from said inlet means, and said discharge compartment being formed with a row of closely spaced solution outlets along substantially the entire length of the discharge manifold, whereby a stream of electrolyte solution delivered into the distribution compartment is distributed thereby to the discharge compartment along the length thereof and is projected with substantially uniform force through each of said outlets.

5. In apparatus for producing sheet metal of electrodeposition, a discharge manifold comprising an elongated tubular member divided by a longitudinal partition into a distribution compartment and a discharge compartment, transverse partitions dividing said discharge compartment into a series of sub-compartments, inlet means for introducing electrolyte solution under pressure into said distribution compartment, said longitudinal partition being formed with a spaced series of openings, each such opening providing communication between one of the sub-compartments of the discharge compartment and the distribution compartment, and such openings becoming progressively larger as they become more remote from said inlet means, and said discharge manifold being formed with a row of discharge openings extending along substantially its entire length, said openings being arranged so that several are provided in each sub-compartiment of the discharge compartment, whereby a stream of electrolyte solution delivered into the distribution compartment is distributed thereby substantially uniformly to each sub-compartment and is projected with substantially uniform force through each of said discharge openings.

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