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**Buzhinskaya et al.**

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[54] **APPARATUS FOR PRODUCING A METAL BAND**


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[52] **U.S. Cl.** ..... **204/208;** 204/216

[51] **Int. Cl.** ..... **B01k 3/02;** C23b 7/02; C23b 7/04

[58] **Field of Search** ..... 204/13, 208, 216, 231



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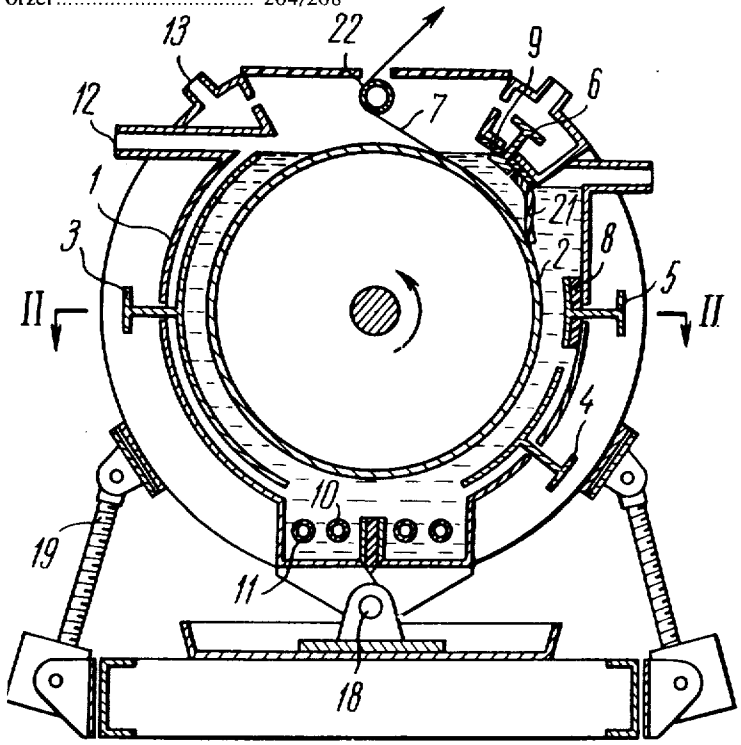


[57] **ABSTRACT**

The method resides in depositing the metal electrolytically on the surface of a cathode from an electrolytic solution, with the current density being successively varied in a plurality of stages: during the first ones of these stages the current density is maintained within a range from 1,000 to 5,000 A/sq.m, during the last stage but one the current density is maintained within a range from 5,000 to 10,000 A/sq.m for a period from 1 second to 300 seconds, during the last stage the current density is maintained within a range from 4,000 to 50,000 A/sq.m for a period from 1 second to 200 seconds, the electrolytic solution being positively agitated during all said stages except the last one.

The apparatus comprises at least three anode plates arranged about the periphery of the cathode drum and radially spaced therefrom within the bath containing the electrolytic solution, the anode plates being connected to the individual power supply sources. The two anode plates, which are the last ones in the direction of the progress of the metal band, have the ratio of the respective surface areas thereof within a range from 15:1 to 5:1. The inter-electrode space, pertaining to the last one of these anode plates, is separated by a partition from the rest of the internal space of the bath.


**4 Claims, 2 Drawing Figures**



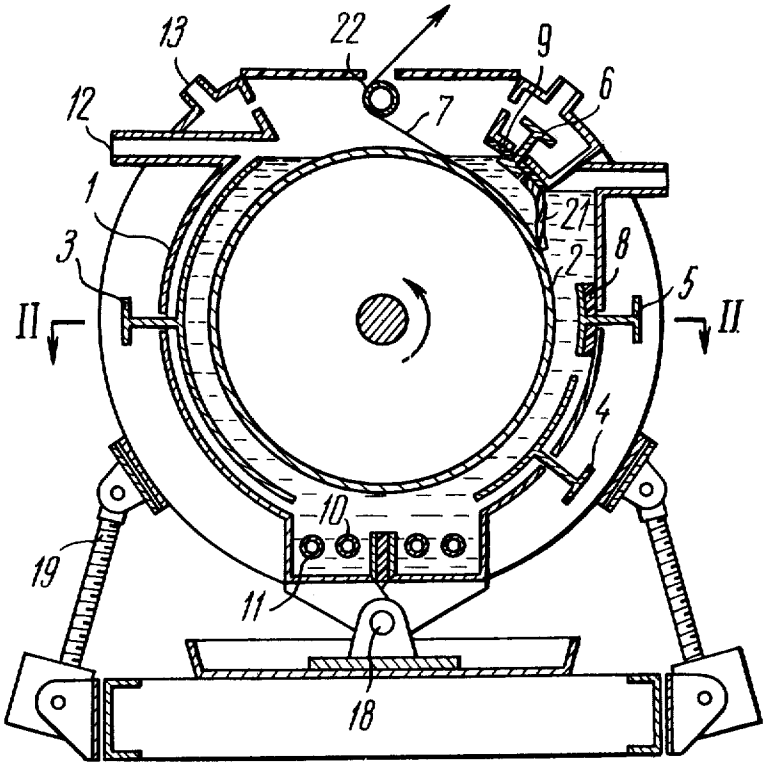



FIG. 1

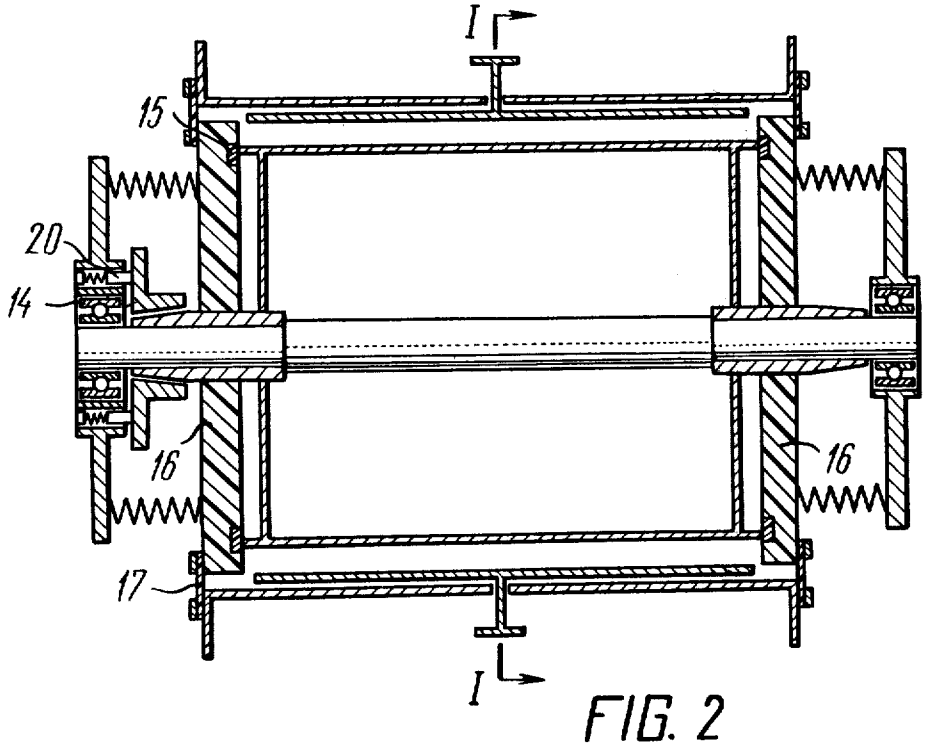



FIG. 2

# APPARATUS FOR PRODUCING A METAL BAND

This is a divisional, of application Ser. No. 251,737, filed May 9, 1972, now U.S. Pat. No. 3,799,847.

The invention relates to methods of production of metal bands and to apparatus for accomplishment of such methods, which are used in non-ferrous metallurgy, in the electronics industry and in electrical engineering for the manufacture of thin metal bands.

Widely known in the art is a method of producing a metal band by depositing the metal electrolytically from an electrolytic solution on the surface of the cathode, with the current density above 1,000 Amperes per square metre, with the electrolytic solution being positively agitated, and an apparatus employing this method, comprising a bath containing the electrolytic solution, incorporating barbotage means for agitating this solution, this bath having mounted interiorly thereof a cathode drum and a plurality of anode plates mounted about the periphery of said drum.

The metal band produced by the above known method and apparatus has a smooth side contacting the cathode and the opposite side which is mat, the surface of this opposite side being unsufficiently developed.

Such band cannot be used for the manufacture of dielectric articles without additional treatment in a specially designed apparatus, since the strength of its adhesion to the dielectric layer proves to be insufficient.

A disadvantage of the known methods and apparatus for production of metal bands of the kind referred to is also the necessity of additionally re-winding the band, which results in repeated breakages of the band, whereby the yield of quality product is brought down.

It is an object of the present invention to provide a method of producing a metal band and an apparatus for accomplishment of this method, which should be capable of producing the metal band and of having one side of this band treated on a single cathode.

With this object in view, the invention resides in a method of producing a metal band by depositing the metal electrolytically from an electrolytic solution on the surface of a cathode with the current density being above 1,000 Amperes per square metre and with said electrolytic solution being positively agitated, in which method, in accordance with the invention, said process of electrolytic deposition is performed with a single cathode, with the current density being successively varied in a plurality of stages, said current density being maintained during the first ones of said plurality of stages within a range from 1,000 Amperes per square metre to 5,000 Amperes per square metre, said current density being maintained during the stage preceding the final one of said stages within a range from 5,000 to 10,000 Amperes per square metre for a period from 1 second to 300 seconds, said current density being maintained during said final stage within a range from 4,000 to 50,000 Amperes per square metre for a period from 1 second to 200 seconds, said electrolytic solution being positively agitated during all said stages except said final one. In this way it has become possible to produce a metal band having one side thereof smooth and the other side thereof rough with a higly developed surface, providing for sufficient strength of adhesion to a dielectric layer.

For accomplishment of this method, there has been provided an apparatus comprising a bath containing the electrolytic solution, said bath incorporating barbotage means for agitating said electrolytic solution, and a cathode drum mounted interiorly of said bath, at least three anode plates being mounted interiorly of said bath about the periphery of said cathode drum, in which apparatus, in accordance with the present invention, said anode plates are electrically connected to their respective individual power supply sources, the two of said anode plates, which are the last ones in the direction of the progress of said metal band, having the ratio of the respective surface areas thereof within a range from 15:1 to 5:1, the inter-electrode space within said band, pertaining to said anode plate which is the last one in the direction of the progress of said metal band, being separated from the rest of the internal space of said bath by a partition means.

Thus it has become possible to obtain a required metal band and to have one of the sides thereof treated to a desired effect within a single apparatus on a single cathode.

Given below is a detailed description of an embodiment of the invention, with reference being had to the accompanying drawings, wherein:

FIG. 1 is a cross-sectional schematic view of an apparatus embodying the invention;

FIG. 2 is a sectional view taken along line II — II of FIG. 1.

Referring now in particular to the appended drawings, the apparatus comprises a metal housing 1 (FIG. 1) consisting of two all-welded titanium semi-cylinders, the housing also acting as an electrolytic bath. Positioned interiorly of this bath is a cathode drum 2. Positioned about the periphery of the cathode drum 2 and radially spaced therefrom are anode plates 3, 4, 5 and 6. The anode plate 3, which is the first one in the direction of the progress of the band 7, is secured on the first one of the two semi-cylinders making up the housing 1, while the anode plates 4, 5 and 6 are secured in succession on the other one of the two semi-cylinders. The anode plates 3 and 4 are connected to a common source of power supply, and the anode plates 5 and 6 are connected, respectively, to their individual-different sources of power supply, whereby the two last-mentioned anodes are mounted on the housing 1 with the insulating members 8 and 9, respectively, interposed therebetween. The apparatus is provided with barbotage means 10 for agitating the electrolyte in the bath with the help of air streams. Manifolds 11 are disposed in the bottom portion of the housing 1 for introduction of the electrolyte into the housing, while overflow pockets 12 are provided in the upper portion of the housing 1, through which the electrolyte leaves the bath. The air and the anode gases are withdrawn from the internal space of the housing 1 through exhaust ventilation pipes 13. The cathode drum 2 is journalled for rotation in bearings 14 (FIG. 2) and is imparted rotation by an appropriate drive mechanism (not shown in the appended drawings). To prevent deposition of copper on the end faces of the cathode drum 2, these end faces are protected with rings 15 made from an acid-resistant dielectric material. The rings are secured in spring-biased end covers 16. Annular diaphragms 17 are interposed between the end covers 16 and the respective ends of the housing 1.

To facilitate mounting, dismantling, inspection and routine maintenance of the apparatus, the left-hand and the right-hand semi-cylinders of the housing 1 can be easily swung aside from the cathode drum 2, the

semi-cylinders in this case being pivoted about a pivot axis **18** with the help of the respective actuators **19.**

The herein disclosed apparatus is supplied with electric power from three different current sources, the respective negative poles of the three sources being jointly connected electrically to the cathode drum **2** through brush contacts **20,** whereas the positive poles of the three current sources are individually connected with the respective ones of the anode plates. As it has been mentioned hereinabove, the first current supply source supplies current to the anodes **3** and **4,** the second current supply source supplies current to the anode plate **5,** and the third current supply source supplies current to the anode plate **6.** In the direction of the progress of the band **7** each successive anode plate has the surface area which is smaller than that of the preceding anode plate. This feature of the herein disclosed apparatus is explained, as follows: the anode plates **3** and **4** are intended for formation of the metal band, as such; the anode plate **5** is intended to ensure sufficient roughness of the surface of this metal band, while the anode plate **6** — the last in the succession — is intended to ensure formation of an adhesion layer with a highly developed surface on the rough side of the band. The surface areas of the respective anode plates is determined by the time needed for each one of the abovementioned processes. For example, when a 35 micron thick metal band is produced, the ratio of the surface areas of the two anode plates **5** and **6,** which are the last ones in the direction of the progress of the band, equals (15 to 5):1.

The inter-electrode space pertaining to the anode plate **6** which is the last one in the direction of the progress of the metal band **7** is separated from the rest of the internal space of the bath by an elastic partition **21** slidingly engaging the periphery of the cathode drum **2,** the partition being made from a resilient dielectric material.

The herein disclosed apparatus operates, as follows.

The electrolyte is introduced into the bath through the inlet manifold **11.** Air is supplied through the barbotage means **10** to agitate the electrolyte, and the power supply to the anode plates **3, 4** and **5** is switched on, with the cathode drum **2** kept immovable. An appropriate time is given under these condition for a layer of metal to be deposited on the cathode drum **2.** Then the drive imparting rotation to the cathode drum **2** is engaged. As the cathode drum **2** thus set into rotation, the metal deposit in the form of a band advancing from the electrolyte is separated from the surface of the cathode drum **2** and is threaded over a guiding roller **22.** Thereafter the power supply to the anode plate **6** is switched on, to apply an adhesion layer on the metal cathode deposit being formed.

The metal deposit is primarily formed on the cathode drum **2** adjacent to the anode plates **3** and **4,** the current density being from 1,000 A/sq.m to 5,000 A/sq.m; then, as the cathode drum with the metal deposit thereon passes adjacent to the anode plate **5,** the respective current density in this area in maintained within a range from 5,000 A/sq.m to 10,000 A/sq.m (i.e. the density here approaches the critical value), and thus within a period from 1 second to 300 seconds the exposed surface of the metal deposit acquires the necessary roughness. As the cathode drum **2** rotates further on, the metal deposit enters the zone adjacent to the anode plate **6,** separated from the rest of the internal space of the bath by the partition **21.** Here, in the space between the anode plate **6** and the cathode drum **2,** the current density is maintained within a range from 4,000 A/sq.m to 50,000 A/sq.m. (i.e. above the critical value), and thus within a period from 1 second to 200 seconds there is deposited an adhesion layer which is an electrolytic deposit with a highly developed surface. This final stage of the processing of the surface of the metal deposit takes place in the zone where the electrolyte is relatively calm, i.e. where the electrolyte is practically not agitated.

In operation of the herein disclosed apparatus the electrolyte is continuously recirculated. The inter-electrode space pertaining to the anode plate **6** communicates with the general volume of the electrolyte through the overflow outlet pocket **12** and also through the gaps (not shown) left between the ends of the partition **21** and the respective ones of the two end covers **16.**

The abovedescribed method can be employed for production of a metal band within a wide range of thicknesses, for example, from 10 microns to 110 microns. The required thickness of the metal band being produced is obtained by selecting the appropriate speed of the rotation of the cathode drum **2.**

## EXAMPLE

Thirty-five micron thick metal band is produced, as follows. Copper band is deposited onto the titanium cathode drum from sulfuric acid - based electrolyte containing 250 to 275 grams per litre of blue vitriol (sulfuric copper) and 70 to 90 grams per litre of free sulfuric acid, at a temperature of 35°C, and air agitation, the current density being 2,500 A/sq.m. (the anode may be either a soluble one, or a non-soluble one).

The duration of the first stage, i.e. of the deposition stage, is 6 minutes 27 seconds. Then the second stage is commenced. During this stage the above conditions of the electrolysis are maintained the same, but the current density is increased to 5,000 A/sq.m, i.e. to the value approach in the critical one. During the third stage of the process the electrolyte is no longer agitated, and the current density is increased to a value above the critical one, i.e. to 7,500 A/sq.m. The duration of the third stage is 1.5 seconds.

When the abovedescribed process is completed, the band is removed from the cathode, washed and dried. The foil thus obtained is ready for manufacture of materials incorporating copper foil.

Materials incorporating the copper band thus obtained have displayed stability of the strength of the adhesion of the band to the dielectric layer, both over the delivery period and after having been tested for galvanic stability, thermal stability and resistance to moisture, unlike oxidized band which is apt to have the strength of the adhesion considerably affected by such tests (see Table **1** hereinbelow).

Table 1

| Sample of band-incorporating material NFD-type | Adhesion strength, grams/cm | | | | |
|---|---|---|---|---|---|
| | Delivered in the state of manufacture | After galvanic stability test | After exposure to 180°C during 100 hours | After exposure to 95% humidity for 48 hours | After exposure to 265°C for 10 seconds |
| Band obtained by the herein disclosed method, 35 micron thick | 1640 | 1600 | 1475 | 1620 | 1925 |
| Oxidized band | 1650 | 1100 | 100–200 | — | — |
| Permissible value, not below | 1500 | — | 700 | 800 | 1000 |

The herein disclosed method of producing metal band and the apparatus employing this method make it possible to obtain metal band of which one side can be continuously processed within a single apparatus.

What is claimed is:

**1.** Apparatus for production of a metal band comprising: a housing for holding an electrolytic solution; an inlet and outlet for the electrolytic solution mounted in said housing; air feed means disposed in the lower portion of said housing for agitating the electrolytic solution; a cathode drum mounted within said housing; a plurality of anodes disposed about the periphery of said cathode drum in said housing, said anodes being connected to individual sources of power, said anodes providing for electrodepositing on said cathode drum of a primary metal layer and a secondary metal layer having a roughened surface, the cathode current density opposite the anodes intended for the deposition of said secondary roughened metal layer onto said primary metal layer being higher than that opposite the anodes intended for the deposition of said primary metal layer; a partition engaging the periphery of the cathode drum for forming a chamber with a quiescent electrolyte zone created therein, said chamber accommodating an individual anode whereby onto said secondary roughened metal layer a dendritic metal layer having high bond strength is electrodeposited.

**2.** The apparatus of claim **1** wherein at least three plate anodes are employed.

**3.** The apparatus of claim **1** wherein the two ultimate plate anodes in the direction of rotation of the cathode drum are insulated from said housing and from each other.

**4.** The apparatus of claim **1** wherein the cathode drum mounted in said housing functions as a common cathodic means in relation to all the anodes employed, thereby providing for depositing onto said cathode drum a primary metal layer, followed by depositing onto the surface of said primary metal layer a secondary roughened metal layer and treatment of the roughened surface of said secondary metal layer so as to obtain thereon a dendritic metal layer exhibiting high bond strength.

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