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Bolz et al.

[11] 3,855,108
[45] Dec. 17, 1974

[54] CONTINUOUS STRIP ELECTROPLATING APPARATUS

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[73] Assignee: Dr. Eugene Durrwachter Doduco, Pforgheim, Germany

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[21] Appl. No.: 436,116

[30] Foreign Application Priority Data

May 17, 1973 Germany 2324834

[52] U.S. Cl. 204/206, 204/15, 204/28, 204/274, 204/DIG. 7

[51] Int. Cl. C23b 5/58, C23b 5/68, C23b 5/72

[58] Field of Search 204/28, 206–211, 204/DIG. 7, 15

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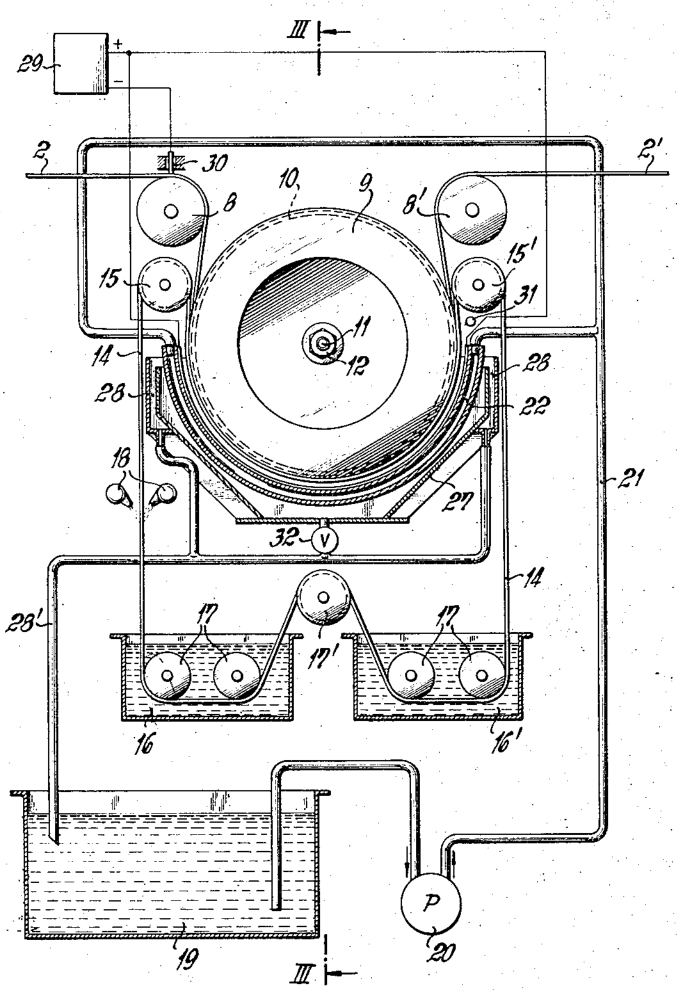
Primary Examiner—F. C. Edmunson
Attorney, Agent, or Firm—Hans Berman; Kurt Kelman

[57] ABSTRACT

Conductive strip material to be electroplated is guided in an arc of about 200° about the insulating circumferential face of a wheel while electrolyte is discharged radially inward toward the strip from a tubular, semicircular anode carrier through aligned apertures in the carrier and in a platinum anode strip on the carrier. Portions of the front side of the strip are protected from contact with the electrolyte by one or more tensioned, elastomeric masking bands moving with the strip and masking the strip edges. The bands hold the back of the strip engaged with a resilient insert in the wheel, thereby masking the back of the strip.

6 Claims, 8 Drawing Figures



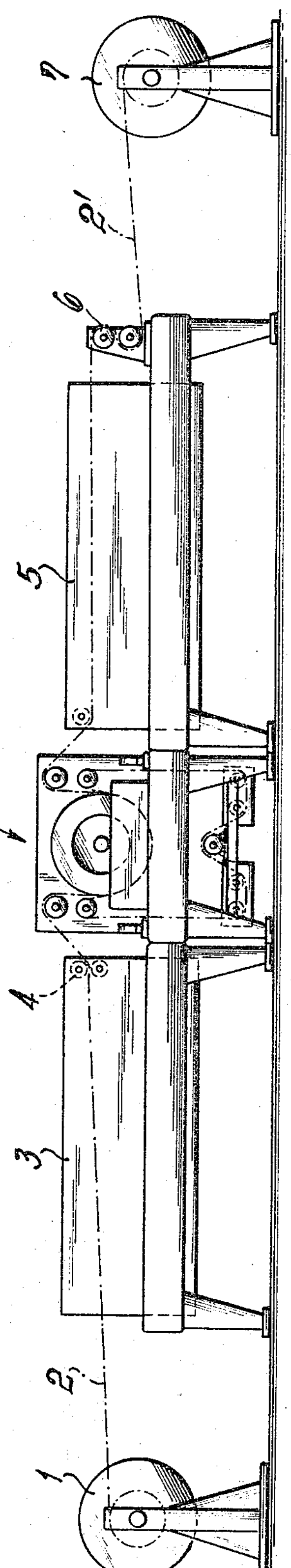
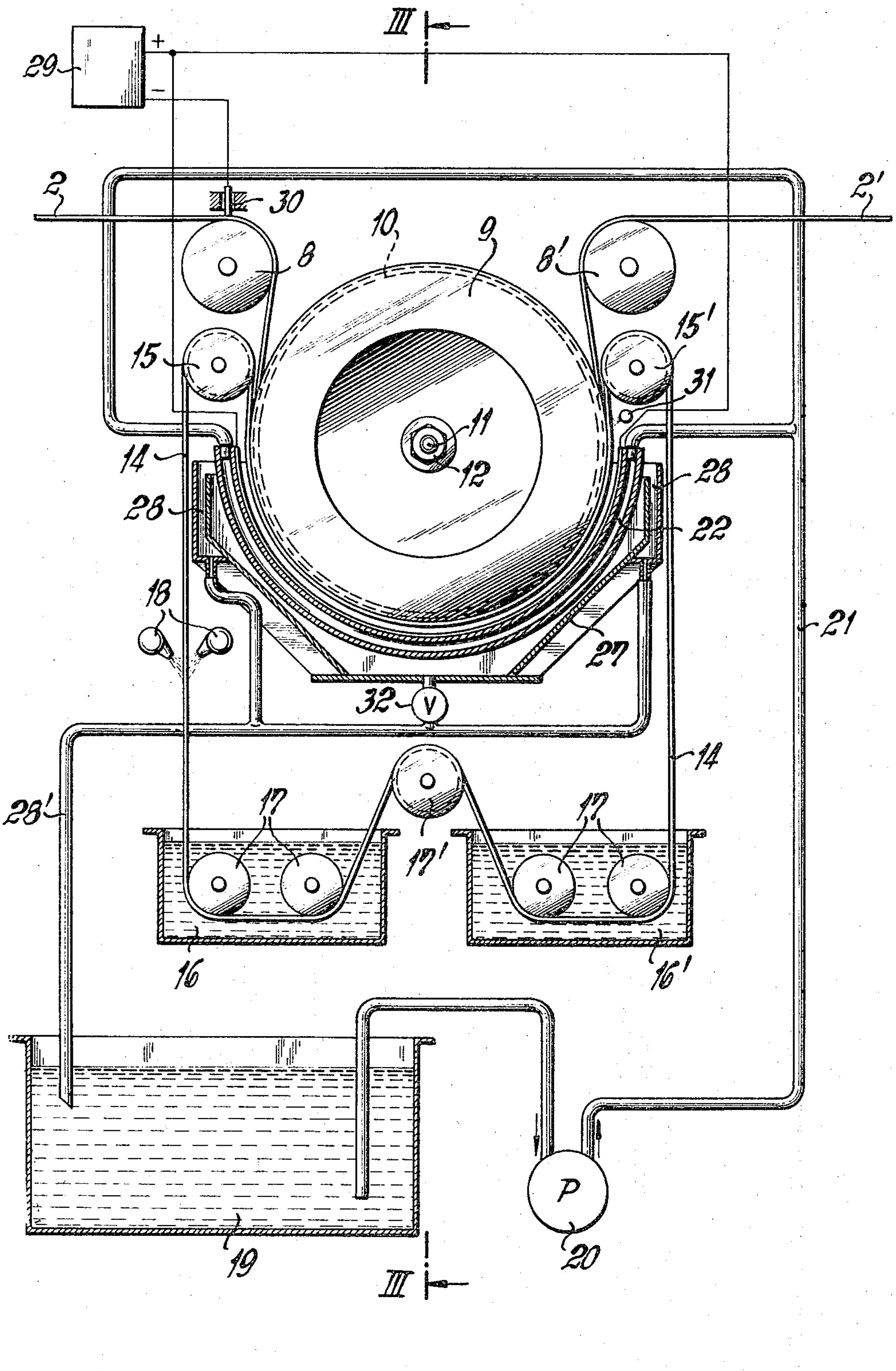


FIG. 1

FIG. 2


III
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+
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2'
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8'
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15'
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28
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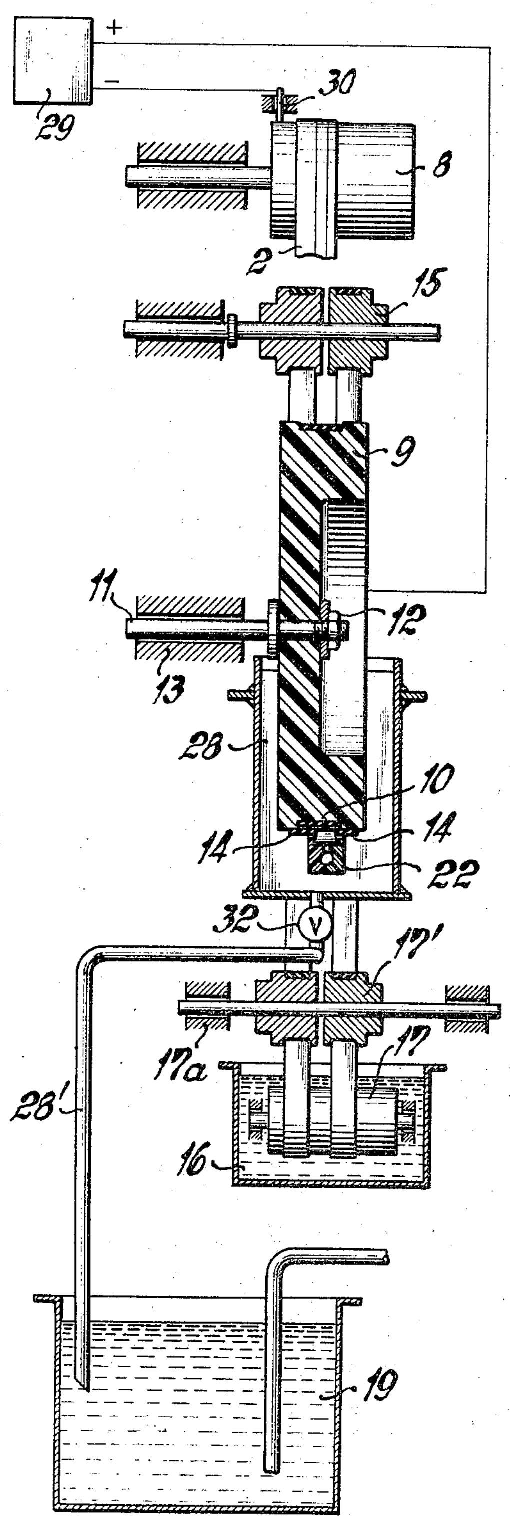
III

FIG. 3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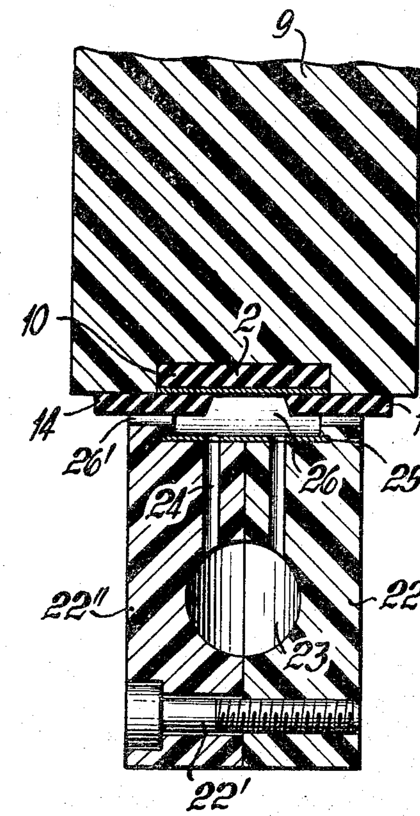
19

FIG. 4


9
10
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14
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26'
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25
24
22''
22
23
22'

FIG. 5

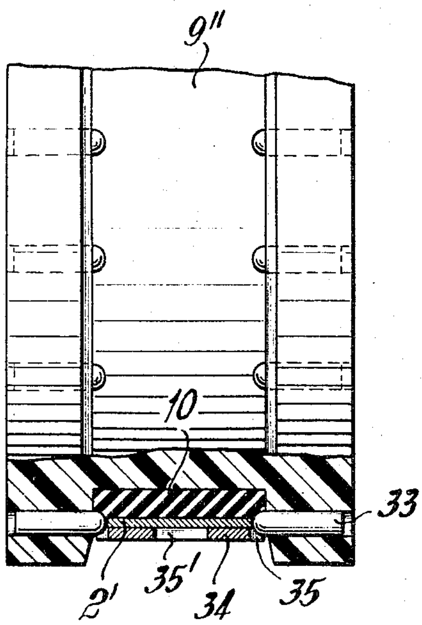


FIG. 6

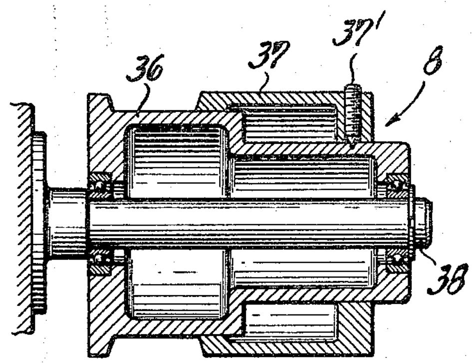


FIG. 5A

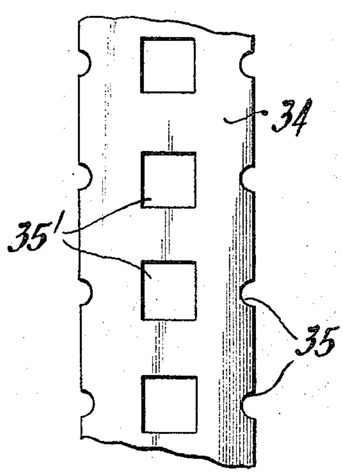
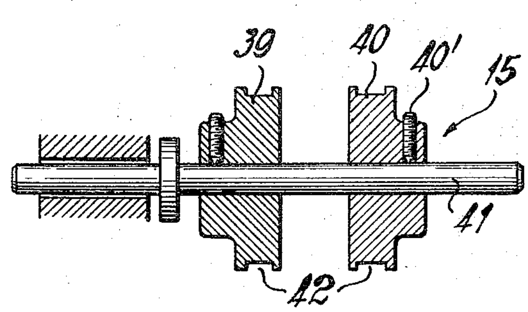


FIG. 7



CONTINUOUS STRIP ELECTROPLATING APPARATUS

This invention relates to the electroplating of continuously moving elongated strip material having a conductive surface, and particularly to the selective electrodeposition of metallic coatings on only a portion of one face of the strip material.

In our copending application Ser. No. 406,559, filed on Oct. 15, 1973, we disclosed apparatus for electroplating strip material in which the strip material moves longitudinally while in contact with the circumference of an assembly of disc members which jointly constitute a wheel formed with a circumferential groove. A portion of the groove is sealed in a radially outward direction by the strip material being plated and encloses an anode. Electrolyte is pumped continuously into the groove to replenish the metal deposited on the cathodic strip material and to provide the vigorous agitation necessary for electrodeposition at the high rates required for economical operation.

While the apparatus of our earlier application has been operated successfully, it is relatively complex and correspondingly costly to build and to maintain. One of the objects of this invention is the provision of continuous strip electroplating apparatus which is simpler to build and capable of operating over extended periods without maintenance or overhaul.

With this object and others in view, as will presently become apparent, the apparatus of the invention provides a wheel mounted for rotation about an axis and having at least a circumferential face of insulating material. The longitudinally moving, elongated strip which it is desired to electroplate is guided into engagement with the insulating face of the wheel over an arc whose length is predetermined by the configuration of the guiding device, and is preferably 180° or more. A tubular anode carrier mounted on the stationary support of the apparatus extends about the wheel and the engaged strip approximately in the afore-mentioned arc. A conductive anode member is mounted on the carrier spacedly opposite the circumferential face of the wheel, and aligned discharge orifices in the carrier and the anode member are directed toward the axis of rotation of the wheel. Conductors connect the strip to the negative terminal of a source of electroplating current, and connect the anode member to the positive terminal. A conduit communicating with the interior of the anode carrier supplies electrolyte for discharge from the orifices of the carrier and of the anode member.

Other features and many of the attendant advantages of this invention will readily be appreciated as the same becomes better understood by reference to the following detailed description of preferred embodiments when considered in connection with the appended drawing in which:

FIG. 1 shows a strip plating installation of the invention in side elevation;

FIG. 2 illustrates the plating unit in the installation of FIG. 1 in side-elevational section on a scale larger than that of FIG. 1, and partly in a conventional manner;

FIG. 3 shows the apparatus of FIG. 2 in section on the line III—III;

FIG. 4 shows a portion of the apparatus of FIG. 3 on a greatly enlarged scale;

FIG. 5 illustrates a modified detail for the apparatus of FIG. 3 in a view corresponding to that of FIG. 4;

FIG. 5A shows a masking band for use in the device of FIG. 5 in fragmentary plan view;

FIG. 6 is an axially sectional, enlarged view of a guide pulley for the strip to be plated in the apparatus of FIG. 3; and

FIG. 7 similarly shows a guide pulley arrangement for masking bands in the same apparatus.

Referring now to the drawing in detail, and initially to FIG. 1, there is shown a strip electroplating installation according to the invention on a scale too small to permit a detailed representation of the inventive features. The bare strip **2** to be plated is drawn from a rotatably mounted supply reel **1** and through a pretreating unit **3** by a first set of motor-driven pinch rolls **4**. The pretreating unit, conventional in itself, sequentially sprays an alkaline detergent solution, rinse water, pickling acid, rinse water, a neutralizing solution, and again rinse water against the traveling strip, and the liquid is blown from the strip as far as possible by air jets before it enters the plating unit **50** with which this invention is more particularly concerned. The pre-treatment described is based on the assumption that the strip will be plated in the unit **50** from a cyanide bath, and obvious modifications in the pre-treatment are necessary if nickel plating from an acid plating bath is contemplated.

The electroplated strip **2'** is drawn from the plating unit through an after-treatment unit **5** by a second set of pinch rolls **6** which is coupled with the rolls **4** to maintain constant tension in the strip **2, 2'** while it passes the plating unit. The after-treatment unit includes rinsing and drying devices conventional in themselves. The electroplated, dry strip **2'** is wound on a take-up reel **7** which is rotated by an electric motor through a slipping clutch in a manner well known and not illustrated.

The electroplating unit **50** is better seen in FIGS. **2** and **3**. Only as much of the stationary supporting structure of the unit has been shown as is needed for an understanding of its operation without crowding the drawing. Conductive pulleys **8, 8'** guide the bare strip **2** toward a plastic wheel **9** and the plated strip **2'** away from the wheel. The strips are freely rotatable on respective shafts parallel to the horizontal shaft **11** on which the wheel **9** is fastened by means of a locknut **12**. The shaft **11** is journaled in a bearing **13** of the stationary supporting structure. The pulleys **8, 8'** are mounted above the wheel **9** on opposite sides of a vertical plane of symmetry through the axis of rotation of the wheel **9** in such a manner that the strip **2, 2'** is trained over the circumferential face of the wheel **9** in an arc of approximately 200° enveloping slightly more than the lower half of the wheel.

The strip is held tightly engaged with the circumferential wheel face over this arc by its own longitudinal tension and by two endless masking bands **14** of synthetic rubber. Each band **14** is trained over the wheel **9** by two pulley arrangements **15, 15'** as described above with reference to the pulleys **8, 8'** and the strip **2, 2'**. The portion of each band **14** remote from the wheel **9** sequentially passes through rinsing water on pairs of pulleys **17** in troughs **16, 16'** and over a tensioning pulley **17'** between the rinsing troughs, the shaft of the pulley **17'** being mounted on slides **17*a***, which may be shifted vertically on the supporting structure and secured in an adjusted vertical position in a manner conventional in itself and not illustrated, to take up any slack in the bands 14. Adhering rinse water is blown from the bands 14 by hot-air jets 18 before the bands return to the wheel 9.

The wheel 9, pulleys 8, 8′, pulley arrangements 15, 15′, and pulleys 17, 17′ are freely rotatable on the supporting structure and are rotated by the strip 2, 2′ in response to the action of the driven pinch rolls 4, 6. The direction of rotation of the wheel 9 is counterclockwise, as viewed in FIG. 2. There is no relative movement between the wheel 9 and the engaged portions of the strip 2, 2′ or the bands 14.

An open storage sump 19 arranged in the base of the plating unit 50 holds electrolyte which is driven by a pump 20 into a discharge conduit 21 during operation of the unit. Respective branches of the conduit 21 are connected to the two ends of a tubular anode carrier 22 which is elongated in a circular arc of about 180° about the axis of rotation of the wheel 9 closely adjacent the circumferential face of the wheel and the portions of the strip 2, 2′ and masking bands 14 which engage the wheel face.

The lower half of the wheel 9 and associated elements are received in a vessel 27 fixedly mounted on the supporting structure of the plating unit 50 and equipped with two overflow chutes 28 approximately diametrically opposite each other relative to the shaft 11. They lead to a return conduit 28′ and the sump 19.

The terminals of a rectifier 29 are connected by respective conductors to a brush 30 engaging a portion of the pulley 8, and to an anode mounted on the carrier 22 in a manner presently to be described. Air jets 31 directed against the bands 14 where they leave the vessel 27 drive adhering liquid from the band surfaces back into the vessel. A draincock 32 connecting the lowermost portion of the vessel with the return conduit 28′ permits the vessel to be emptied of liquid by gravity, but is closed during normal operation of the plating unit.

As is better seen in FIG. 4, a shallow groove in the circumferential face of the wheel 9 receives an annular rubber cushion 10 of rectangular cross section as an insert. Its outer face is approximately flush with the lands of the circumferential wheel face on either side of the groove when in the relaxed condition. The cushion 10 is compressed slightly by the strip 2 whose width is smaller than that of the cushion-receiving groove by a minimal clearance not capable of being shown in the drawing. When tensioned, the strip 2, 2′ thus is guided by the radial side walls of the wheel 9 in the circumferential groove. The two masking bands 14 are guided about the wheel 9 in such a manner that they are superimposed partly on the lands of the wheel 9 and partly on the edge portions of the strip 2, 2′.

The anode carrier 22 consists of two semi-circular, flat pieces of plastic which are mirror images of each other and are tightly assembled by means of bolts 22′ so that grooves in the carrier pieces jointly define the bore or cavity 23 of the carrier which connects the two branches of the conduit 21. The convex face of the carrier 22 is recessed and holds an elongated piece 25 of sheet platinum constituting the anode of the plating unit and connected to the rectifier 29 as described above and not shown in detail, conductors leading from both longitudinal ends of the anode 25 to the positive terminal of the rectifier.

The anode 25 is flanked axially by integral ribs 22″ of the carrier 22 which define the effective width of the anode and are separated from respective masking bands 14 by narrow, radial gaps 26′ leading axially outward of a chamber 26 which extends in an arc about the wheel 9, is open at its circumferential ends, but is otherwise sealed, except for the gaps 26′, by respective face portions of the cathodic strip 2, 2′, the bands 14, the ribs 22″, and the anode 25. Elongated radial bores 24 in the two pieces of the anode carrier 22 communicate with the longitudinal bore 23 and with aligned discharge orifices in the anode 25. The anode carrier 22 is fixedly suspended in the vessel 27 in a manner not explicitly shown.

The pulleys 8, 8′ are identical, and details of their structure are evident from FIG. 6 which shows the pulley 8 in axial section. The body portion 36 of the pulley 8 is of stepped cylindrical shape, and it is partly enveloped by an approximately cup-shaped, coaxial cover portion 37 axially adjustable on the body portion 36 and provided with a set screw 37′ for securing the cover portion 37 in a selected axial position. The rim of the cover portion 37 and an axially terminal flange, which constitutes the widest part of the body portion 36, bound a guide groove in the pulley 8 whose width may be adjusted by axially shifting the portion 37 to suit strips 2, 2′ of different width. It is generally preferred to replace the wheel 9 by one equipped with a narrower or wider cushion 10 if strips of different width are to be plated.

The guide pulley arrangement 15 is shown in detail in FIG. 7, and the pulley arrangement 15′ is identical. Two pulleys 39, 40 are mounted on a common shaft 41, and may be adjusted axially on the shaft when set screws 40′ are released. Circumferential grooves 42 conformingly receive the two masking bands 14 respectively during operation of the plating unit, and the axial spacing of the two bands on the strip 2 may be varied by shifting the pulleys 39, 40, thereby modifying the width of the edge portions of the strip which are masked by the bands 14.

During operation of the apparatus, strips 2 is uncoiled from the supply reel 1, prepared for plating in the pre-treatment unit 3, and pulled under moderate tension through the plating unit 50. Electrolyte is pumped from the sump 19 into the anode carrier 22 and discharged under pressure through the orifices in the anode 25 radially inward into the plating chamber 26 and toward the exposed central portion of the strip 2. Electric current passing through the electrolyte in the chamber 26 from the anode 25 to the strip 2 causes metal deposition on the strip. The chamber 26 and the vessel 27 are filled with electrolyte somewhat beyond the level of the overflow chutes 28, and the electrolyte partly stripped of its metal content returns to the sump 19. It may be replenished in the sump in any conventional manner.

Only the central portion of the strip 2 is plated, the edge portions and the back being shielded against current passage by the bands 14 and the cushion 10. The plated strip, after leaving the vessel 27, passes through the after-treatment unit 5 and is reeled on the take-up reel 7 for further use. Adhering electrolyte is blown back into the vessel 27 from the bands 14, and residual electrolyte is removed in the rinsing troughs 16. Only insignificant amounts of rinsing liquid can pass the air jets 18 so that dilution of the electrolyte is avoided when the bands 14 again enter the plating chamber 26.

FIG. 4 represents actual dimensional relationships in a preferred embodiment of the invention. The cross section of the plating chamber 26 is uniform, as shown, over practically the entire circumferential length of the chamber. The exposed width of the strip 2 is about one half of the exposed width of the anode 25 so that the cathode current density is twice the anode current density. The flow section of the gaps 26' is somewhat greater than the combined flow section of the bores 24. Electrolyte flow into the chamber 26 is radial, and flow outward of the chamber is predominantly axial, very little electrolyte being discharged circumferentially from the longitudinal ends of the chamber 26. The flow rate of the electrolyte is readily chosen to replace the electrolyte in the chamber 26 more than once a second.

The change in the direction of flow through the chamber 26 and the high pumping rate cause intensive turbulence in all parts of the chamber 26, and extremely high current densities (about 40 amps./dm^2) and deposition rates are readily accomplished with suitable electrolytes, known themselves. The voltage drop across the chamber 26 due to the ohmic resistance of the electrolyte is minimal because the spacing of the parallel cathode and anode surfaces is not significantly greater than one half the width of the exposed cathode surface, and of the order of 5 millimeters. Electrode polarization is low because of the intensive agitation provided.

The length of the chamber 26 is many times greater than any other dimension of the chamber so that the dwell time of the strip 2 in the effective plating zone is relatively long, a feature essential for adequate thickness of electrodeposit at high traveling speeds of the strip. The low electrode potentials required to produce the large current flow favor deposition of ductile deposits of silver and other metals from known high-speed plating electrolytes. The deposits formed are of uniform thickness over the entire exposed width of the cathode because of the much wider anode. The opposite edges of the masking bands 14 are beveled, as is seen in FIG. 4, so that the body of electrolyte flares from the strip 2 toward the anode 25, and thinner deposits adjacent the masked, bare parts of the plated strip 2' are avoided.

The discharge of hydrogen at the cathode cannot be avoided entirely in any electroplating arrangement operating under production conditions, and co-deposited hydrogen causes embrittlement in many electrodeposited metals, particularly silver. The cathode efficiency is high in the apparatus of the invention up to high cathode current densities because of the configuration of the chamber 26 and of the severely turbulent liquid flow through the chamber. The oxygen unavoidably deposited on the platinum electrode 25 is carried away before it can reach the strip 2, 2' and affect the quality of the cathodically deposited metal.

While the operation of the plating unit 50 has been described with reference to the electrodeposition of silver from an alkaline, more specifically, a cyanide plating bath, other metals obviously may be electroplated to equal advantage by means of the same equipment, and changes, if any, will readily be made in details, as in the nature of the insoluble anode 25 to fit the electrolyte. If necessary, the circulating electrolyte may be filtered, cooled, or heated in a manner not requiring explicit description, and the replenishment of the electrolyte with metal lost by deposition is well known and not part of this invention.

Strips of bronze, brass, nickelsilver, and laminar strips consisting of two metals having dissimilar coefficients of thermal expansion which are coated with silver, gold, nickel, or other metals along their centers while the edge portions are bare, are staple articles of commerce and are employed widely for manufacturing electrical contacts. However, the apparatus of the invention is capable of producing strips selectively electroplated over parts of one surface in patterns other than that inherent in the location of the masking bands 14 shown in FIG. 4.

One of the bands 14 may be omitted if it is desired to keep only one longitudinal edge bare of electrodeposited metal. A further modified masking arrangement is illustrated in FIG. 5 and is suitable for producing blanks for lead frames in semi-conductor devices.

The wheel 9' differs from the afore-described wheel 9 by a somewhat deeper circumferential groove whose bottom is provided with a rubber cushion 10 for the purpose described above. Registration pins 33 project from axial bores of the wheel 9' into the circumferential groove in circumferentially uniformly spaced relationship. Instead of two masking bands 14, the strip 2'' to be plated is partly covered with a single masking band 34 having the same width as the strip. The band 34 consists of a thin stainless steel strip having uniformly spaced registration notches 35 in its two edges and square apertures 35', each aligned with two notches transversely of the direction of band movement. The band, after being provided with the notches 35 and apertures 35' on a punch press, and being welded into a closed loop, is coated with a layer of synthetic rubber to protect the stainless steel from contact with the electrolyte, and trained over the wheel 9' in a manner obvious from FIGS. 2 and 3, the apparatus shown in FIG. 5 being identical with the first-described embodiment of the invention as far as not explicitly shown otherwise. The strip 2'' is provided with notches corresponding to the notches 35, and the strip and masking band 34 are guided about the wheel 9' in such a manner that precise registration is maintained by the points of the pins 33 simultaneously engaging the lateral notches in the band and strip.

Plastics, such as rigid polyvinyl chloride, are the preferred materials of construction for the apparatus of the invention to prevent stray currents from building deposits on the plating unit where none are wanted, but suitably insulated metallic elements may be substituted. For example, only the circumferential face of the wheels 9, 9' needs to consist of insulating material. Other changes will readily suggest themselves to those skilled in the art.

It should be understood, therefore, that the foregoing disclosure relates only to preferred embodiments of the invention, and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purpose of the disclosure which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

What is claimed is:

1. Apparatus for continuously electroplating a longitudinally moving elongated strip having a conductive surface comprising, in combination:

a. a support;
b. a wheel mounted on said support for rotation about an axis and having a circumferential face of insulating material;
c. guide means for guiding said moving strip into engagement with said face over a predetermined arc;
d. a tubular anode carrier mounted on said support and extending about said wheel and said strip substantially in said arc;
e. a conductive anode member mounted on said carrier spacedly opposite said face,
   1. said carrier and said anode member being formed with respective aligned discharge orifices communicating with the interior of said carrier and directed toward said axis;
f. conductive means for connecting said strip and said anode member to respective terminals of a source of electroplating current; and
g. a conduit communicating with said interior for supplying electrolyte to said carrier.

2. Apparatus as set forth in claim 1, further comprising an endless masking band of flexible, electrically insulating material, said guide means including means for guiding said masking band in masking engagement with a selected portion of said strip while said strip is being guided over said arc, said band being interposed between said strip and said anode member.

3. Apparatus as set forth in claim 2, further comprising an annular insert of resilient insulating material on said wheel, said insert constituting said circumferential face.

4. Apparatus as set forth in claim 2, further comprising washing means for washing electrolyte from said masking band, and drying means for drying the washed masking band, said guiding means including means for guiding said band in a closed loop sequentially over said arc, said washing means, said drying means, and back to said wheel.

5. Apparatus as set forth in claim 4, further comprising tensioning means for tensioning said masking band.

6. Apparatus as set forth in claim 2, wherein said guide means include a row of circumferentially spaced registration pins on said wheel, each pin having an axially directed point, said band being formed with a plurality of lateral notches, said points engaging said notches in the portion of said band in masking engagement with said strip.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,855,108 Dated December 17, 1974

Inventor(s) WALTER BOLZ ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading, line [73], change

"Assignee: Dr. Eugene Durrwachter Doduco, Pforgheim, Germany" to

-- Assignee: Dr. Eugen Dürrwächter DODUCO, Pforzheim, Germany --

Signed and sealed this 11th day of March 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks