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Selker

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[54] **METHOD AND APPARATUS FOR CONTINUOUS PRODUCTION OF NICKEL FOIL**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 836,822, June 26, 1969, abandoned.

[52] **U.S. Cl.** **204/13,** 204/208, 204/216, 204/281

[51] **Int. Cl.** **C23b 7/02,** B01k 1/00, B23n 1/00

[58] **Field of Search** 204/12, 13, 281, 204/208, 216

[56] **References Cited**

UNITED STATES PATENTS

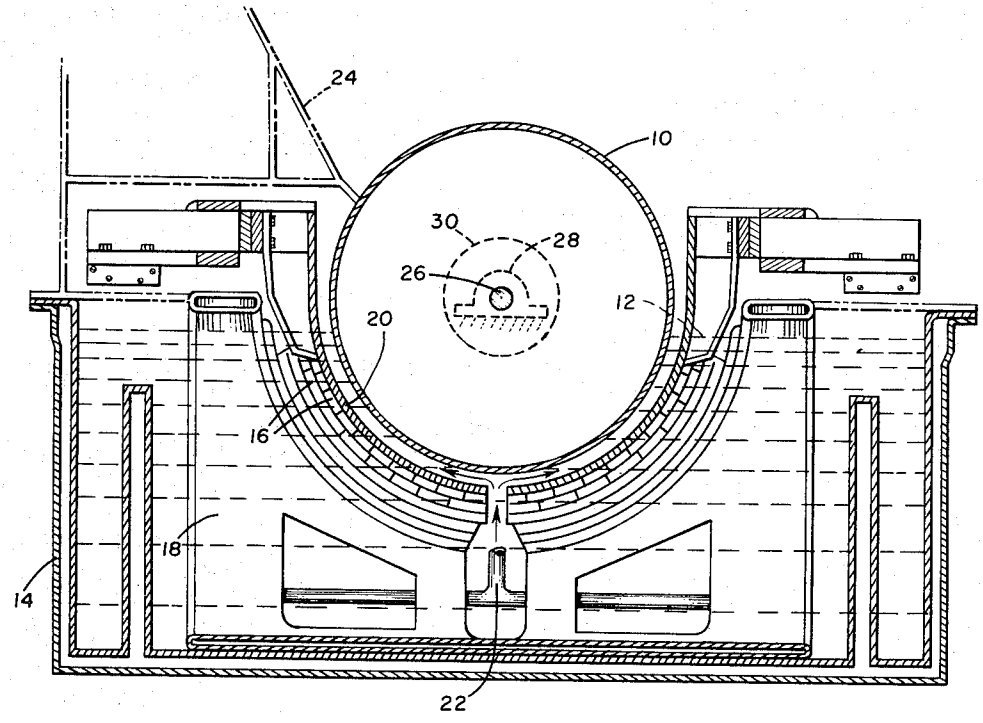
3,461,046	8/1969	Clancy	204/13
2,646,396	7/1953	Dean	204/12

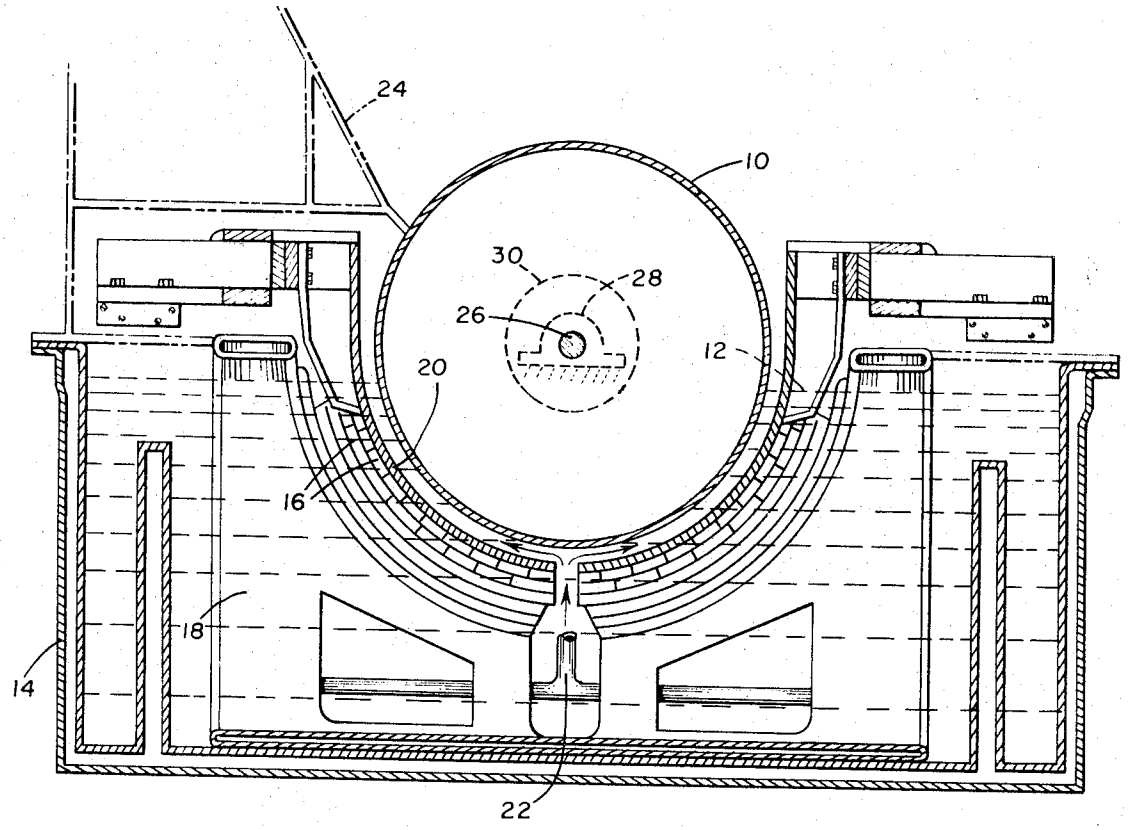
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[57] **ABSTRACT**

A method and apparatus for continuously producing pure, solid, and pore-free nickel foil by electrodeposition, utilizing a cathode drum of titanium.

4 Claims, 1 Drawing Figure




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METHOD AND APPARATUS FOR CONTINUOUS PRODUCTION OF NICKEL FOIL

This application is a continuation-in-part of my U.S. Pat. application, Ser. No. 836,822, filed June 26, 1969, and now abandoned.

The present invention relates generally to a method using an improved apparatus for continuously producing nickel foil by electrodeposition.

Nickel foil enjoys some specialized use in printed circuitry because of the strength, high temperature stability, and ease of welding nickel metal to itself and other components of the printed circuit. To be so used, the nickel foil must satisfy some certain requirements such as purity, homogeneous crystallinity, evenness, and absence of porosity. While purity of the foil can be attained with relative ease, its even and/or non-porous surface has been difficult to accomplish because of its direct relationship with the cathode surface.

Heretofore, plating devices for producing electroformed nickel foil have utilized mandrels comprising stainless steel drums or steel drums plated with thin layers of copper, nickel, and chromium, respectively. In each case, the exterior surface of the drum must be kept highly polished.

Generally, the plating solution and the plating process will cause cracks, pits, and/or imperfections on the drum's surface which becomes unsuitable for nickel foil production. It is necessary, therefore, to stop production periodically to maintain the high polish on the drum. Such stoppages are quite costly as they can occur every few weeks.

It is a principal object of the present invention to provide an apparatus for the continuous production of pure and pore-free nickel foil.

A further object of the invention is to provide a plating drum on which pure and pore-free nickel foil is continuously electrodeposited, said drum being essentially maintenance free.

A cathode drum comprising in part a relatively thin titanium metal cylinder has been suggested in the past, see French Pat. No. 1,540,378, for making copper foil. The drum includes a support structure of lead arranged in close proximity to the titanium cylinder. The lead support constitutes a lining having a greater coefficient of expansion than titanium to provide close contact between the two surfaces at the operating temperature. According to the patent this is required to provide a uniform current distribution, by way of the lead lining, through the titanium cylinder.

The titanium cylinder and the supporting structure of the above-mentioned French patent must be machined to very close tolerances in order to provide electrical contact throughout the drum surface. The temperature of the bath must be kept at such a relatively high level so that the contact between the two cylinders, due to expansion, is maintained. While such requirements may be satisfactory for the production of copper foil, they are not desirable for the production of nickel foil.

It has been found that the difficulties of evenly distributing the current across a titanium drum is related to the axial length of the drum and these difficulties can be removed and sufficient electrical conductivity can be established by keeping the drum to a minimum dimension as disclosed herein. This eliminates the need for a conductor lining as suggested in the above Patent and thus avoids problems of lead contamination.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

The single FIGURE drawing shows an elevational view partly in section of an apparatus for electrodeposition.

Referring to the accompanying drawing, there is shown an end view of the plating apparatus wherein the cathode drum **10** is mounted to rotate in plating solution **12,** bearings and driving mechanism not shown. The cathode drum may be of any suitable diameter and length depending on the particular size of nickel foil desired. A drum of about four feet in diameter and 24 inches long has been found particularly suitable. A tank **14** holds the plating solution **12** in contact with the bottom half of cathode drum **10.** Washing, cleaning, and drying devices, not shown, are normally mounted on the tank **14** or in the proximity thereof. Conforming anodes **16** are closely situated to the cathode drum's exterior surface and are held by supporting units **18** which extend axially the full length of the drum. Pure metallic nickel chips and pieces comprise the anodes which are generally covered by a diaphragm **20** comprising a permeable cloth acting as a filter to prevent small anode particles from causing a rough plate. This diaphragm **20** can be of any suitable material such as muslin cloth. Also mounted in the tank **14** is a piping system **22** which, by pump action, circulates rapidly the plating solution in the direction of the arrows between the drum and the anode, thus maintaining agitation and concentration of said plating solution.

The drum **10** is rotatably mounted about a central shaft **26,** supported by a bearing **28** at each axial end, and carrying at each such end a current collector ring **30.** An electron potential source conducts current to the rings **30** from which the current passes radially through drum end plates (not shown) into drum **10.** A suitable conventional foil take-up reel (not shown) may be mounted on a frame **24** and may be mechanically linked to the shaft **26.**

The cathode drum constitutes the most essential feature of the plating apparatus, and I have found that a drum made out of titanium metal or its alloys has been particularly advantageous in the production of pure, solid, and pore-free nickel foil. Moreover, the titanium drum has been found to require essentially no maintenance over a period of about one year, thus eliminating the disadvantages of periodic stoppages necessary with prior art drums.

The titanium cathode drum of the present invention is a unitary, self-supporting structure, preferably made from a solid titanium billet of suitable dimensions. By the piercing and ring-rolling process, the billet attains a cylindrical shape having a continuous solid surface. After attaining the proper size and thickness the drum is then machined and polished by suitable means. Because of the high chemical resistance of titanium metal and/or its alloys, the finished polish on the surface can be maintained over a long period of time compared to that of stainless steel or chrome-plated steel drums. The ring-rolled, seamless titanium drum presents the advantage of having a weld-free surface. Generally, welds used in manufacturing drums are of different hardness and crystal structure than the parent metal and consequently will receive a different luster or ap-

pearance during polishing operation. This difference in appearance will be imparted to the nickel foil which becomes commercially undesirable. Furthermore, the welded areas may be porous, which would render the nickel foil correspondingly porous and thus unacceptable for printed circuit use.

As to the electrolytic bath used, it is preferably of the nickel sulfamate type which comprises 120 g/l nickel metal, 40 g/l boric acid, 7.5 g/l nickel chloride hexahydrate, and 0.05 percent of anti-pit additive. The pH is preferably in the range of 3.9 to 4.1 and the operating temperature between 50°–55° C. To produce a nickel foil having 2 mil thickness and utilizing a current density of 135 asf, the surface speed of the drum is 4 inches per minute. Similarly, for 1 mil thickness, the speed is doubled, i.e., 8 inches per minute. The ring-rolled, seamless drum is preferably of sufficient thickness to be self-supporting, i.e., a thickness of over three-eighths of an inch is satisfactory. The polishing of the drum's surface is accomplished by machining. The final, smooth finish is effected via abrasive belt finishing techniques utilizing belts coated with silicon carbide particles. Other polishing agents can be used, however.

For continuous operation and free maintenance, it is essential that the drum's surface is not injured or bruised, although minor and shallow scratches are not very critical as they can be removed by simple machining and/or polishing operation.

The titanium drum needs no protective coating in or out of operation. It is believed that a thin layer of oxide which forms on the drum's surface serves, firstly, as a means or protection and, secondly, as a means of allowing the nickel foil layer to strip off the drum with ease.

It has been found that a ring-rolled, seamless drum made of a titanium alloy comprising essentially 6 percent aluminum, 4 percent vanadium, and the balance titanium, and known as 6 Al–4V titanium alloy, is very satisfactory as a maintenance-free cathode drum. This 6 Al–4V–Ti drum has operated continuously for one year without any sign of deterioration or need of maintenance.

It is to be understood that the present invention is not limited to the precise construction, as herein discribed and illustrated, but embraces all such variations and modification as are within the scope of the invention as set forth in the following claims.

What is claimed is:

1. A method for making nickel foil from an electrolytic solution comprising the steps of:

placing a solution of nickel compounds into a tank to partially immerse the outside surface of a cathode drum mounted for rotation in said solution and having a unitary, seamless, self-supporting circumferential surface composed exclusively of titanium or an alloy thereof;

providing a nickel anode in said solution which conforms to and is in proximity with an immersed portion of said cylindrical surface;

electrically energizing the cathode;

rotating the drum while agitating the solution to plate a film of nickel on said surface; and

stripping said film from said surface.

2. A method according to claim **1** including the step of filtering small nickel particles which may pass from said anode to said cathode.

3. A method for making a nickel foil from an electrolytic solution comprising the steps of:

placing a solution of nickel compounds into a tank;

continuously passing outside surface portions of a unitary, seamless, self supporting, titanium or titanium alloy cathode drum into and out of said solution;

providing a nickel anode in said solution which conforms to and is in proximity with immersed portions of said surface portions;

electrically energizing the cathode;

agitating the solution; and

stripping nickel foil from said surface.

4. A method according to claim **3** including the step of filtering small nickel particles which may pass from said anode to said cathode.

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