Dec. 11, 1956 A. WESLEY ET AL 2,773,816

METHOD FOR ELECTROREFINING METAL AND IMPROVED ELECTROLYTIC METAL PLATES PRODUCED THEREBY

Filed Aug. 2, 1952 2 Sheets-Sheet 1

Fig. 3.

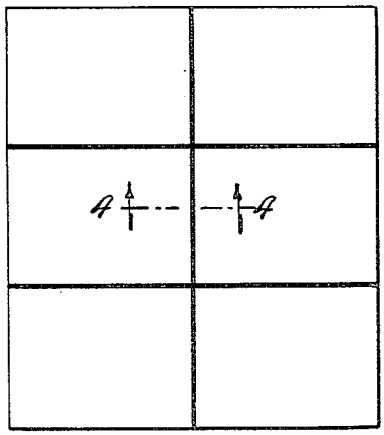


Fig. 4.



Fig. 5.

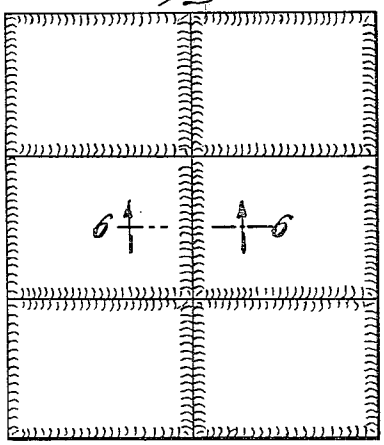


Fig. 6.

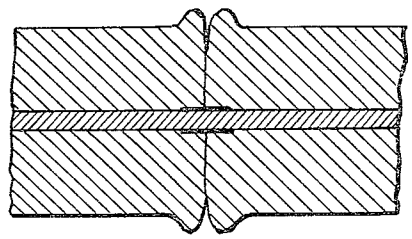


Fig. 7.

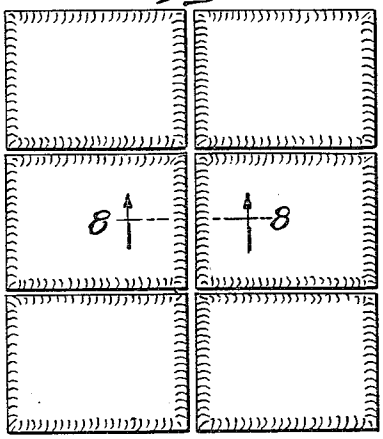
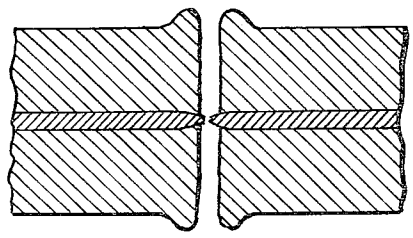


Fig. 8.



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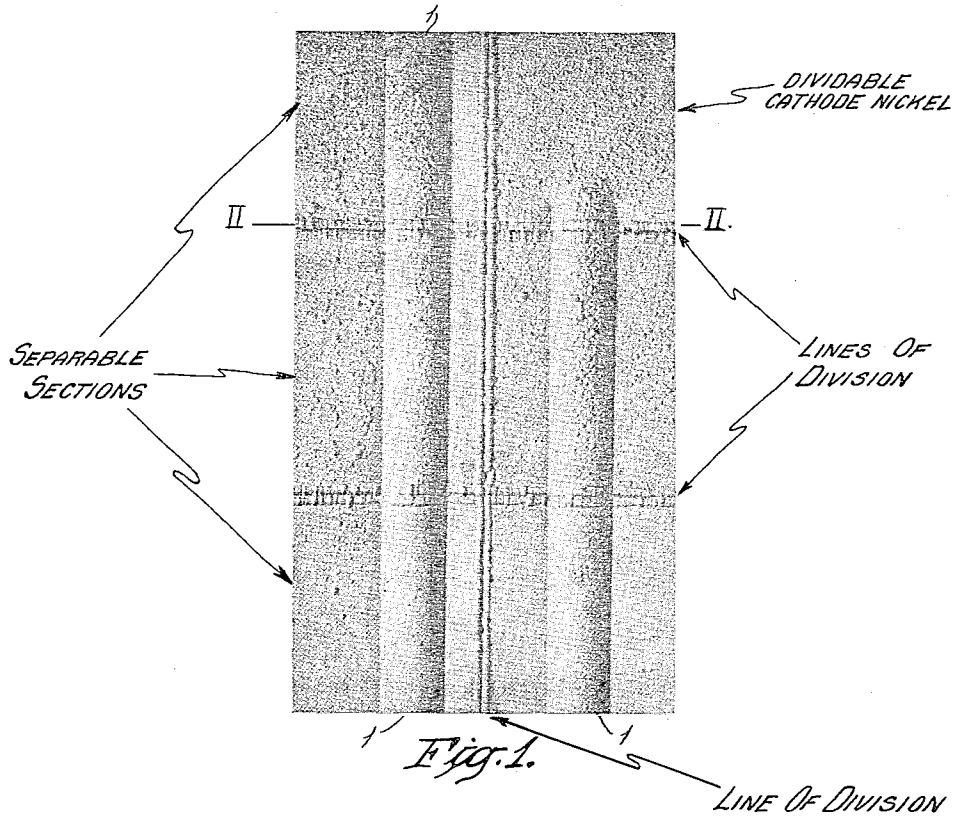


Fig. 1.

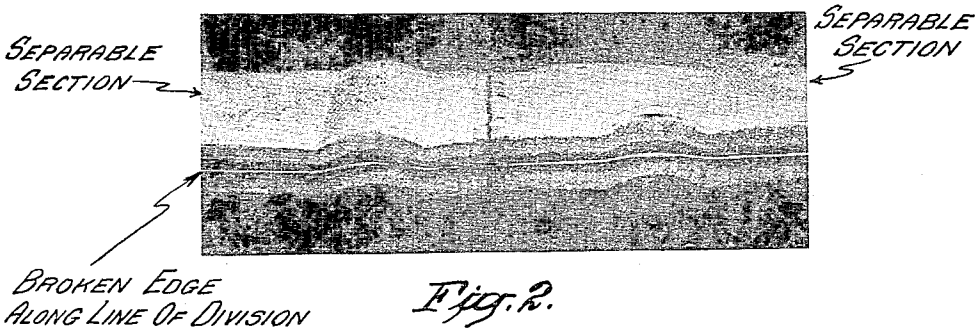


Fig. 2.

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METHOD FOR ELECTROREFINING METAL AND IMPROVED ELECTROLYTIC METAL PLATES PRODUCED THEREBY

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Application August 2, 1952, Serial No. 302,304

7 Claims. (Cl. 204—12)

The present invention relates to cathodes and cathode starting sheets for the electrolytic recovery of metal and, more particularly, to a method for producing cathode metal plates which are readily separable, dividable, or breakable along at least one line in a major face of the plates into pieces of predetermined smaller area, and to the product produced by said method.

Attempts have been made to provide readily dividable or separable cathode metal plates, e. g., electrolytic nickel cathode plates. Metal cathodes produced in electrolytic refineries are customarily produced only in a standard size convenient to the refining process. When, as frequently happened, other smaller sizes of cathode sheet were required for industrial uses, the cathode sheets had to be sheared to the desired smaller size. Such shearing was an expensive operation requiring a powerful and expensive machine and much manual handling of the awkward cathode sheets.

A customary method employed in electrolytic refineries to produce cathode metal is to grow thin cathode starting sheets of the metal to be recovered by plating upon an inert metal cathode, such as a stainless steel or an aluminum cathode, thereafter to strip the thin metal sheet, called "starting sheet," from the inert cathode and to use this "starting sheet" as a cathode in the electrorefining operation to grow a cathode metal sheet approximately 3/8 to 1/2 inch thick. Metal is usually electrodeposited simultaneously upon both sides of the starting sheet in producing the final cathode metal sheet. The cathode sheets of tough, ductile metals such as nickel, copper, etc., obtained in this manner are usually very tough and difficult to shear.

Prior attempts have been made to solve the problem solved by the present invention. Thus, U. S. Patent No. 2,392,614 to Prescott utilized slots cut in the starting sheet to create lines of weakness in the electrolytic metal, but this method suffers the disadvantage that the slots cannot be cut completely across the starting sheet and it is found that the portions of the final cathode metal sheet corresponding to the unslotted portions left to hold the starting sheets together are as tough and hard to divide as the remaining electrolytic metal away from the original locations of the slots and these tough portions make it difficult to divide the metal yield rough, ragged edges when broken by bending.

Although attempts were made to overcome the foregoing difficulties and other difficulties, none, as far as we are aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that metal starting sheets used in electrorefining operations can be treated such that the resulting electrolytic metal sheets can be readily parted or divided into pieces of smaller area to give clean edges at predetermined lines entirely across the major faces of the sheet; yet these electrolytic metal sheets are sufficiently strong to withstand normal shocks and stresses in handling.

It is an object of the present invention to provide a method whereby metal cathodes are obtained in electrorefining which are dividable into metal sheets of predetermined smaller dimension.

It is a further object of the invention to provide a method whereby dividable cathode metal sheets may be produced in electrorefining without interfering with the normal operation of the electrorefining process.

Another object of the invention is to provide a process for producing electrolytic nickel cathodes which are readily separable at predetermined lines extending across the electrolytic or cathode nickel sheet into sections of predetermined smaller area, said sections being characterized by substantially smooth, straight edges.

The invention also contemplates providing electrolytic metal cathode sheets which are readily dividable along predetermined lines on the major faces of the cathode into pieces of smaller area.

It is a further object of the invention to provide electrolytic nickel cathode sheets which are readily dividable into pieces of the same thickness but of smaller area and which have smooth, straight edges.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a reproduction of a photograph taken at about three-fourths actual size and depicting the side view of a portion of a dividable nickel cathode produced in accordance with the present invention;

Figure 2 is a reproduction of a photograph taken at full size and depicting the fractured edge of a portion of a dividable nickel cathode after said cathode had been fractured along a predetermined line established by the process embodying the present invention.

Figure 3 is a view in elevation of a starting sheet prepared according to the invention;

Figure 4 is an enlarged partial cross-sectional view of the starting sheet of Figure 3, taken on the line 4—4 thereof;

Figure 5 is a view in elevation of an electrolytic metal plate produced according to the invention;

Figure 6 is an enlarged partial cross-sectional view of the plate of Figure 5, taken on the line 6—6 thereof;

Figure 7 is an elevational view of the plate of Figure 5 after it has been broken into sections by bending; and

Figure 8 is an enlarged partial cross-sectional view of two adjacent sections of the broken plate of Figure 7, taken on the line 8—8 thereof.

Generally speaking, the present invention contemplates dividable or separable electrolytic metal cathodes, e. g., nickel cathodes, and a method for producing the same comprising forming thin metal starting sheets (e. g., sheets about 1/32 inch in thickness but having substantial breadth and width to form the major faces thereof), preferably of the metal being produced electrolytically and of about the area of the desired final electrolytic sheet; applying at least one line of a non-conducting resist across at least one face of said starting sheet, said line having a substantial width correlated to the thickness of the final cathode sheet; and thereafter depositing metal upon said face of said starting sheet to build up the cathode to a desired final thickness sufficient to cover said lines of resist. When metal is deposited upon both sides of the starting sheet simultaneously, the desired lines of resist are applied in corresponding or registering locations on opposite sides of the starting sheet.

The dividable or breakable cathode metal plates provided by the invention comprise a metal starting sheet having at least one line of resist of critical width applied to at least one side thereof and a plate of electrolytic metal deposited upon said side to cover completely said

line of resist. As an example, satisfactory results are obtained using a resist line about one-eighth inch wide when the electrolytic metal deposited upon the surface of the starting sheet having said resist line applied thereon is about three-sixteenths inch thick.

The term "resist" as used herein means a material which can be applied to a metal surface in the form of an adherent, non-conducting coating resistant to the dissolving action of solutions used for cleaning and for electroplating upon such surfaces and includes non-conducting inks, lacquers, paints, varnishes, tapes, and/or films which may be applied in the form of lines having little thickness to the faces of the starting sheets.

When the lines of resist having critical width are applied to the faces of the starting sheets as contemplated in the present invention and metal is electrodeposited thereon, metal is not deposited initially upon the areas covered by the lines of non-conducting resist. However, in carrying out the present invention, metal is electrodeposited upon the special starting sheet prepared in accordance with the invention until the electrolytic metal deposit completely covers over the line or lines of resist. In this manner, lines of division corresponding to the location of the originally applied lines of resist are created in the final electrolytic cathode metal plates along which the cathode metal plates may be parted or divided with comparative ease to leave clean, straight edges; yet the cathode metal plates are sufficiently strong and rigid to withstand without breaking the shocks and stresses encountered in shipping. By applying to the starting sheet a plurality of lines of resist which may be parallel, converging, intersecting, etc., in proper patterns such as rectangles, squares, etc., full-sized electrolytic metal plates are produced after electrodeposition upon the thus-prepared starting sheet which may be divided into smaller shapes having required dimensions.

As noted hereinbefore, the lines of resist are applied to a relatively thin metal starting sheet which is usually itself made from electrolytic metal, and the electrolytic metal deposit is built up thereon to form cathode metal plates. The thickness of the starting sheet is governed by practical considerations since the starting sheet must have sufficient stiffness to maintain uniform distance from adjacent electrodes in the electrorefining tanks without waving about or coming in contact with adjacent electrodes and must be thin enough to be free of nodular growths. In the case of nickel electrorefining, starting sheets about 1/32 inch thick are satisfactory. The dividable electrolytic or cathode metal plates produced in accordance with the present invention preferably comprise essentially two plates of relatively thick cathode metal having lines or zones of weakness adhering to opposite sides of a relatively thin starting sheet which is itself a solid piece of metal. Accordingly, these cathode plates preferably are broken along lines corresponding to the original lines of resist by transverse bending first in one direction to break the portion of electrolytic metal which is subjected to tension by the bending action and then by reversing the direction of the bend to break the electrolytic metal on the other side of the starting sheet. The starting sheet itself can then be broken by the application of very little additional pressure in bending. Of course, the dividable electrolytic metal plates can also be broken along the lines of division provided in accordance with the present invention by a single bending operation, but the broken edges are likely to be rougher than when the preferred bending procedure aforementioned is employed. Other methods of dividing the dividable electrolytic metal plates provided by the invention may also be employed, e. g., cutting, shearing, etc. Again, the invention may be employed to produce cathode plates having electrolytic metal plated on only one side of the starting sheet, in which case it is unnecessary to apply resist to the side of the starting sheets which will not be plated.

The accompanying Figures 1 and 2 illustrate a dividable nickel cathode plate provided by the invention. Thus, Figure 1 shows a portion of a dividable nickel cathode plate produced in accordance with the present invention and Figure 2 shows the broken edge and one side of a portion of the dividable nickel cathode shown in Figure 1 after breaking at section II—II. The bulges or humps shown in Figures 1 and 2 and designated by the reference character **1** result from a design embossed in the starting sheet for the purpose of stiffening the starting sheet. In Figure 2, the light-colored line running through the broken edge of the cathode is the thin nickel starting sheet which protrudes an average of only about 0.5 mm. from the fractured face. It will be noted from Figure 2 that the cathode nickel deposited upon the starting sheet has fractured to leave a smooth surface. The cathode metal shown in Figure 2 has also been broken along another line of division extending perpendicularly from the fractured face shown and the cathode metal depicted is held together along said perpendicular line of division by the starting sheet only. The dark areas in the fractured face adjacent the light-colored fracture of the starting sheet represent a relatively non-reflecting portion characterizing the line of division produced in the electrolytic nickel made in accordance with the present invention.

Figures 3 through 8 illustrate successive steps in the preparation and division of a dividable electrolytic metal plate according to the invention. Figure 3 is an elevational view of a starting sheet having a plurality of continuous lines of resist **2** applied across the faces thereof. Figure 4 is an enlarged sectional view of a portion of the sheet of Figure 3, showing the lines **2** on both faces of the sheet in registered or superposed position. Figure 5 shows the finished dividable plate comprising the painted starting sheet on which metal has been electrodeposited to the desired thickness; and Figure 6 is a partial section of the finished plate of Figure 5, illustrating the manner in which the electrodeposited metal bridges over and substantially covers the lines of resist **2**. Figures 7 and 8 illustrate, respectively, elevational and partial cross-sectional views of the plate after it has been broken into sections by bending. It will be noted that the deposited metal has broken smoothly and evenly along lines corresponding to the locations of the lines of resist on the starting sheet.

For the purpose of giving those skilled in the art a better understanding of the invention and/or a better appreciation of the advantages of the invention, the following illustrative example is given:

Example I

A section of a starting sheet 0.031 inch thick was cleaned by degreasing and scrubbing with wet pumice. Continuous lines of resist made of an air-drying lacquer commonly used in electroplating as a stop-off lacquer about 1/8 inch wide were applied at corresponding locations on each side of the starting sheet completely across each face of the starting sheet to mark off the sheet in approximately 3-inch squares. The sheet was thereafter given a pretreatment to promote adherence of electrodeposited nickel comprising anodic exposure for 5 minutes at 80° F. and 15 amperes per square foot in a bath containing about 100 grams per liter sulfuric acid, about 50 grams per liter sodium chloride and about 5 grams per liter copper as copper sulfate. Nickel was then electrodeposited upon both sides of the prepared starting sheet to produce a cathode having a total thickness of about 3/8 of an inch and containing lines of division corresponding to the original locations of the resist lines. A section of the plate about six inches long was broken by bending along a line of division in a tensile machine. A load of 8000 pounds at a bend of 6° broke one side of the deposit, and a load of 7000 pounds at a bend of 6° broke the other side of the deposit. A very straight smooth break was obtained as shown in the accompany-

ing Figure 2. Another joint 3 inches long taken from said cathode was broken by bending, and it was found that the maximum load required to break the deposit on one side of the starting sheet was 1400 pounds at a bend of 14° while the deposit on the opposite side broke at a load of 1000 pounds at a bend of 9°.

In order to show the critical importance of the continuous line of resist having a critical width as contemplated by the present invention, another starting sheet was prepared and electroplated as in Example I with the exception that instead of using the continuous line of resist having critical width as required by the present invention, the starting sheet was marked off on each side thereof with registering but discontinuous rows of the same stop-off lacquer or resist as used in Example I but applied in the form of circular patches about ⅛ inch in diameter and spaced about ⅛ inch apart. Nickel was deposited on both sides of the starting sheet to produce a cathode plate having a total thickness of about 0.350 inch. This plate was broken in a tensile machine by bending a section 2½ inches long along the line where the circular patches of resist had been placed. Three reverse bends of about 45° under a load of 8000 pounds were required to break the said section and a very rough and jagged fracture was obtained.

As indicated hereinbefore, the width of the resist line employed in making the dividable electrolytic plates provided by the invention is a critical feature of the invention. Thus, in one instance, when a final nickel cathode thickness of about ⅜ inch was produced, it was found that the cathode could not be broken by bending in a vise along a line of division resulting from the application upon registering sides of a starting sheet having original resist lines 1/16 inch wide, although the same cathode broke readily when bent in the same manner along a line of division resulting from resist lines ⅛ inch wide. When resist lines wider than the width indicated herein are employed, a strong, heavy bead of electrolytic metal builds up along the edges of the resist line to produce too great a local increase in thickness of deposit at these locations with the result that difficulties may be encountered in the electrorefining cell and that increased force is again necessary to bend or break the finished plate and it is found that there remains along the fractured edge a sharp edge of the original starting sheet protruding beyond the fractured electrodeposit. The following formula affords a convenient means of determining the proper critical width of resist line to employ in carrying out the present invention:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

where

W=width of each resist line in inches,

T=thickness in inches of electrodeposited metal on the face upon which the line (or lines) of resist is applied.

Thus, where metal is electrodeposited on both faces of a starting sheet to yield a cathode having a total thickness of ⅜ inch, i. e., an electrodeposit on each face of about 3/16 inch, the width of each line of resist on each face will be approximately ⅛ inch. If a resist line is used having a width either greater than or narrower than that determined by the above-mentioned formula, the deleterious effects discussed hereinbefore will then result.

Numerous types of resists may be employed in carrying out the present invention, including vinyl resin base paints (such as sold under the mark "Rack Coating No. 266"), synthetic polymer preparations requiring a baking treatment (such as sold under the mark "Unichrome Coating 218X"), air-drying synthetic resin stop-offs (such as sold under the trade mark "Microstop"), chlorinated hydrocarbon waxes applied by melting (such as sold under the trade mark "Halowax"), and insulating impregnated tapes (such as sold under the trade mark "Microtape"). It will be recognized by those skilled in the art that resists such as the foregoing can be applied to metal sheets by conventional means such as brushing, spraying, etc. Certain types of resists can be obtained in tape form and applied per se to the metal starting sheets. It should be borne in mind that certain resist compositions which produce coatings satisfactory for the purpose of creating lines of weakness in cathode metal plates may contain solvents or soluble ingredients which will disturb the characteristics of the plating bath and cause pitting, etc. Accordingly, the particular resist selected should be tested for its effect upon plating bath performance.

An outstanding feature of the present invention resides in the fact that starting sheets can be treated in such manner that the lines of division created in the final cathode sheet can extend to the edge of the starting sheet, i. e., the resist line or the network of resist lines employed can extend completely across the starting sheet. In this manner, difficulties in parting, breaking or dividing the final cathode plate are minimized since no section of the line of weakness produced in the final electrolytic metal plates in accordance with the invention has the strength and toughness of the remaining portions of the cathode metal plate. This is particularly important at the edges of the "as-plated" cathode plate, since normally there is a tendency for the current density to increase at the edges with the result that the plate at the edge frequently has a thick, heavy bead and is proportionally harder to bend or break than the plate at the interior portions of the cathode sheet.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Thus, while the invention has been described principally in connection with the electrorefining of nickel, those skilled in the art will appreciate that the invention is also applicable in the electrorefining of other tough, ductile metals such as copper, etc. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. As a new article of manufacture, a composite dividable electrolytic nickel plate comprising an imperforate nickel starting sheet having a plurality of continuous lines of resist applied at corresponding locations on opposite faces thereof and extending across said faces, and an electrolytic nickel deposit upon said faces covering said lines of resist and having a thickness of nickel deposit upon each face that is related to the width of a line of resist on the face as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of the line of resist and T is the thickness of the nickel electrodeposit on the face to which said line of resist has been applied, said plate being readily dividable into pieces of smaller area having substantially smooth and straight edges by bending along lines corresponding to the locations of said lines of resist.

2. As a new article of manufacture, a composite dividable electrolytic metal plate comprising an imperforate starting sheet having at least one continuous narrow line of resist applied across a face thereof, and an electrolytic metal deposit upon said face covering said line of resist and having a thickness that is related to the width of the line of resist on the face as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of the line of resist and T is the thickness of the metal electrodeposit on the face on which

the line of resist has been applied, said plate being readily dividable into sections of smaller area having substantially smooth and straight edges by bending along at least one line corresponding to the location of said line of resist.

3. A process for producing a dividable electrolytic nickel plate which comprises applying across the faces of a nickel starting sheet a plurality of continuous lines of resist about ⅛ inch wide and in registering locations on each face of said sheet, and electrodepositing nickel upon both sides of said starting sheet to cover said lines of resist and to produce an electrolytic nickel plate about ⅜ inch thick and having a plurality of lines along which said plate is readily dividable into pieces of smaller area by bending along lines corresponding in location to the lines of resist applied to the starting sheet.

4. A process for producing a dividable electrolytic nickel plate which comprises applying across the faces of a nickel starting sheet at least one continuous narrow line of resist at corresponding locations on opposite faces of said sheet, and electrodepositing nickel upon both sides of said starting sheet until said lines of resist are covered with nickel and until a thickness of electrodeposited nickel is obtained which is related to the width of a line of resist on the face as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of line of resist and T is the thickness of metal electrodeposited on the face onto which said line of resist has been applied, to thereby produce an electrolytic nickel plate having at least one line along which said plate is readily dividable by bending corresponding in location to the line of resist applied to the starting sheet.

5. A process for producing a composite dividable electrolytic metal plate which comprises applying across a face of an imperforate metal starting sheet at least one continuous narrow line of resist, and electrodepositing metal upon said face until said line of resist is covered with metal and until a thickness of electrodeposited metal is obtained which is related to the width of the line of resist on the face as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of line of resist and T is the thickness of metal electrodeposited on the face on which said line of resist has been applied, to thereby produce an electrolytic metal plate having at least one line along

which said plate is readily dividable by bending corresponding in location to the line of resist applied to the starting sheet.

6. The process for producing a dividable electrolytic metal plate, which comprises applying across the opposite major faces of a metal starting sheet at least one continuous line of resist at corresponding locations on said faces and electrodepositing on said faces a thickness of metal deposit that is related to the width of a line of resist on the faces as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of the line of resist and T is the thickness of the metal electrodeposited on the faces to which said line of resist has been applied, thereby producing an electrolytic metal plate which is readily dividable by bending along at least one line corresponding in location to the line of resist applied to a metal starting sheet.

7. As a new article of manufacture, a dividable nickel cathode comprising a nickel starting sheet having at least one continuous line of resist extending across each face of said starting sheet and in registering location thereon, and a nickel electrodeposit upon both faces of said starting sheet and embedding said lnies of resist, said electrodeposit of nickel upon each face of said starting sheet being of a thickness that is related to the width of the line of resist on the face as determined by the following formula:

$$W=\frac{2T}{3}\pm\frac{T}{10}$$

wherein W is the width of the line of resist and T is the thickness of the nickel electrodeposit on the face to which said line of resist has been applied, said nickel cathode being dividable into pieces of smaller area having substantially smooth and straight edges by bending along lines corresponding to the locations of said lines of resist.

References Cited in the file of this patent

UNITED STATES PATENTS

426,788	Farmer	Apr. 29, 1890
684,291	McCoy	Oct. 8, 1901
2,392,614	Prescott	Jan. 8, 1946

FOREIGN PATENTS

474,790	Germany	Apr. 13, 1929