

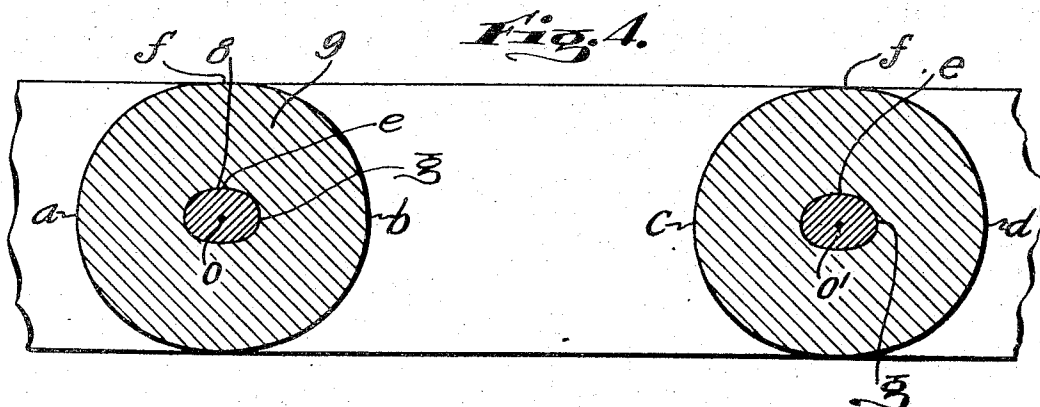
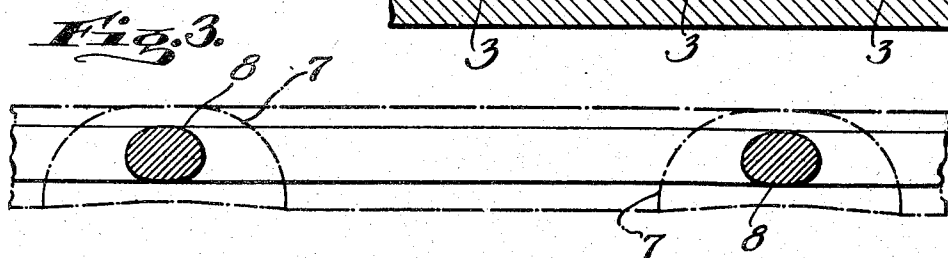
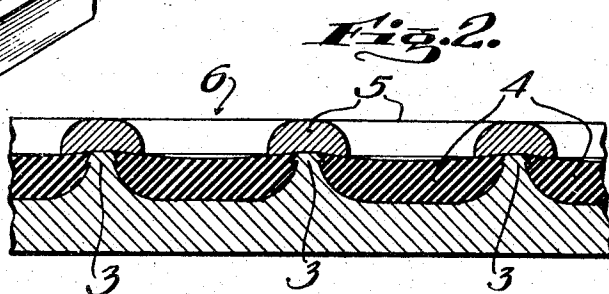
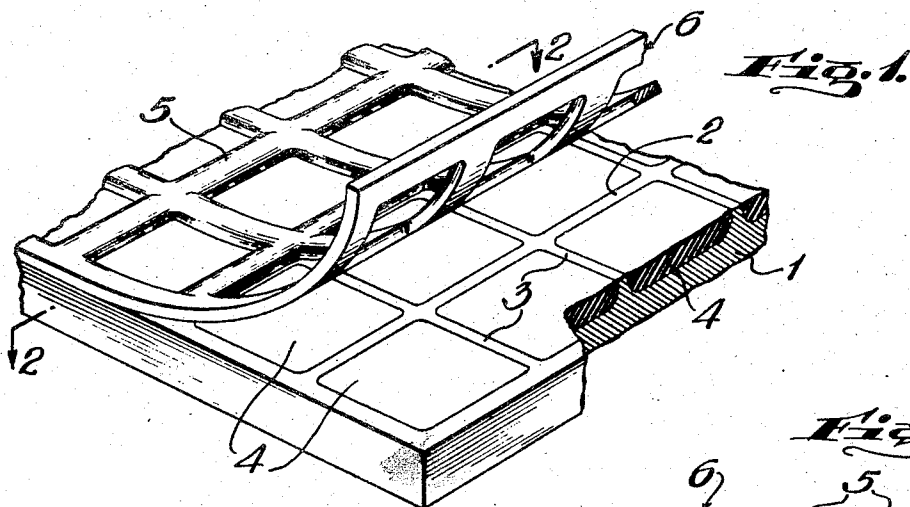
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E. O. NORRIS

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PROCESS OF ELECTROLYTICALLY PRODUCING FORAMINOUS SHEETS

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INVENTOR
EDWARD O. NORRIS

BY *John H. Hilliard*
ATTORNEY

UNITED STATES PATENT OFFICE

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PROCESS OF ELECTROLYTICALLY PRODUCING FORAMINOUS SHEETS

Edward O. Norris, Westport, Conn., assignor to
Edward O. Norris, Inc., New York, N. Y., a corporation of New York

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The invention relates to the production of foraminous sheet chiefly of a character adapted to serve as screen, stencil, or the like, and is carried out mainly by the process of electrolytic deposition. For the sake of brevity, the product will, regardless of the specific use for which it is adapted, be throughout this specification referred to as "screen."

The object broadly is the production of screen of a thickness in excess of that which can be produced simply by electrodeposition thereof on a matrix of the type shown and described in my United States Patent No. 2,166,366, issued July 18, 1939. As this type of matrix and the process of producing it are fully described in my said application, I will at this point merely recapitulate briefly its essential features. The matrix itself consists of a plate of metal or other electrically conductive material capable of receiving an electrolytic deposit, the depositing surface of which exhibits a pattern of crossed spaced bands of conductive material whereby a multitude of areas are delimited, these areas being composed of material passive to electrolytic deposition. In general, this material is in the class of those known as electrically non-conductive, although the essential feature is a surface incapable of causing the formation of an electrolytic deposit and any surface that answers that requirement is sufficient. The non-conductive areas preferably approximate a square in shape, although, as will become apparent, the shape may be varied through a variety of forms.

I have found however that it is difficult to deposit on such a matrix screen of a thickness that is required to meet many commercial needs, for the reason that, although the deposit grows in thickness as the electrolytic action proceeds, it at the same time grows laterally, and, before a structure of the required thickness has been built up, the deposit will have crept over the non-conductive areas and, if not arrested, completely covered them—thus defeating the object in view. If the deposit is arrested in time to leave holes therein of the required area, the deposit itself is thin and insufficient in thickness and strength to meet many commercial requirements.

Another object is to produce by electrolytic deposition screen the surfaces of which are smooth and free from sharp edges and projections. In this connection it is pointed out that an important factor relating to the flexibility and strength of such screen as I am describing is the character of the surface; that is to say, if the surface be rough or the connecting strips be of ir-

regular cross-section area, the capacity of the structure for repeated bending and also its breaking strength are definitely impaired—all in accordance with well-known principles.

An equally important object is to materially reduce the amount of equipment required in a plant manufacturing screen electrolytically. Commercial needs require that screen be available in a number of different materials such as copper, nickel, silver, gold, platinum, and other metals. The matrices that are employed in my process are expensive to make and to maintain, and changing electroplating solution from one metal to another in a single tank is not feasible. As an additional difficulty, electrolytic solutions of a number of metals deposit in such a way as to make ready stripping difficult. By following my invention I am able to produce skeleton screen uniformly of a single metal—say, copper, and then build it up in any metal desired. For example, I can employ only a single matrix installation by which I can produce skeleton screen uniformly of copper and then build the skeleton screen up to the required size in the less expensive electroplating equipment used for that purpose. This advantage is particularly prominent when the skeleton screen is produced continuously in a revolving cylinder equipment, such as is shown and described in my pending application Ser. No. 168,904, filed October 14, 1937. In equipment of this character not only the matrices but also the machines in which they are employed are especially expensive to make and maintain, and the control of the operation is decidedly critical, and obviously it is a decided advantage to dispense with as many of them as possible. In point of fact I find that skeleton screen of copper can be used as a base for the deposit of practically all metals commercially required in electrolytic screen. Copper, as is well known, deposits readily with a minimum of difficulty of control, and it is possible to remove its surface to a considerable depth by the corrosive action and leave a smooth, regular surface. This is in contrast to the method of building the screen throughout of the desired metal. In the latter case it would be necessary to provide as many of the expensive cylinder installations as there are metals used by the manufacturer.

Another object equally as important as the others is a process that can be so controlled that screen of pre-selected characteristics as to cross-section of lands and contour of land section can be produced with a high degree of certainty.

Referring to the drawing,

Fig. 1 is a perspective view of a matrix of the

type above described showing a section of screen which has been deposited thereon electrolytically and then has been partially stripped from the matrix;

5 Fig. 2 is a view on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged view showing in detail the lands of a small portion of the screen of Fig. 2 after the same has been stripped from the matrix and after an intermediate step in the process 10 has been completed;

Fig. 4 is an enlarged view on the scale of Fig. 3 showing a small portion of the completed structure.

Referring more in detail to the drawing, the 15 matrix (Fig. 1) is composed of a plate 1 of electrically conductive material which may be of any one of a number of metals but is preferably of nickel. From this plate rise the lands 2 and the connecting lands 3 which may be of the same material as that of the plate but at any rate present 20 electrically conductive exposed surfaces, the areas 4 delimited by the lands consisting of some electrically non-conductive material, such, for example, as Bakelite, asphaltum, or the like. As 25 the exact nature of the respective materials of the matrix are not important provided they answer the requirements above described, I will not go into further detail concerning it except to call attention to the fact that the surfaces of the 30 lands are approximately flush with the surfaces of the delimited areas 4. Obviously when this plate is employed as a cathode in an electrolytic bath in association with a suitable anode and source of current, a deposit will take place on the 35 lands 2 and 3 of an approximately half-round or half elliptical section and conforming in its pattern to the pattern which these lands exhibit. Such a deposit is indicated by the numeral 5 in Fig. 1 and is shown partly stripped from the 40 matrix as is indicated by the portion 6 of the same figure. It should be noted that the stripping is made readily possible by covering the deposit-receiving surface of the matrix with an extremely thin coat of beeswax before the electro-deposition is begun. The application of the wax is effected by first dissolving it in a comparatively large proportion of thin volatile solvent such as benzine, but, as the method of applying the wax is already well known, I will not go further into it 50 in this description.

It will be noted by reference to Figs. 1 and 2 that the lands are comparatively narrow in width as compared to the width of the non-conductive areas 4; in fact, as shown in the drawings (see 55 Fig. 2), the ratio is about 1 to 8. However, both the absolute dimensions and the relative dimensions depend upon the specifications of the ultimate product as will presently appear.

The reason for the relatively narrow width of 60 the lands of the matrix will be apparent from an examination of Fig. 2, where the deposit is shown as having crept over from the depositing areas on to the non-conductive areas. As this would take place regardless of the width of the 65 lands and, as the extent of creepage is the same regardless of the width of the lands, I prefer to start a deposit on a land of very narrow width.

After the deposited structure has been stripped 70 from the matrix as shown in Fig. 1, it is next subjected to the action of some agency that will very considerably reduce the cross-section dimensions of the connecting lands with the object of producing screen structure that may be used as a base or skeleton for the reception of a further 75 deposit that will build it up to the ultimate dimen-

sions required. Among the purposes served by over-depositing in the first instance and then reducing, instead of arresting the initial deposit at the stage at which the dimensions of the skeleton screen have been reached are the following: 5

(a) Removal of the wax-impregnated surface. In this connection it should be explained that that surface of the stripped screen which has been in contact with the waxed surface of the matrix is impregnated with wax and that it is very difficult to remove the included wax by any cleaning 10 method. By initially depositing to dimensions beyond those required for the skeleton screen, the stratum of wax-impregnated metal may be removed, thus leaving a clean purely metallic surface capable of receiving a strongly adherent deposit.

(b) A smooth surface is produced for the reception of the building-up deposit presently to be referred to. If the surface of the skeleton screen 20 be smooth, the deposit laid thereon will be smooth and free from sharp edges, projections, and other irregularities.

(c) The method which I employ to reduce the section of the connecting lands operates to more 25 rapidly remove edges, projections, and other salient portions than it does to remove the other areas, so that the result is a skeleton screen having better relationships as to land width and thickness than was possessed by the screen as it 30 came from the matrix.

(d) A land section of circular or nearly circular outline.

(e) The skeleton fabric is more resistant to tearing when overdeposited and then cut back. 35

(f) The surface is bright and clean and therefore capable of taking a strongly adherent deposit.

The step of reducing the connecting land dimensions, which I will refer to as "cutting back," 40 may be accomplished by subjecting the screen after it is removed from the matrix to the action of an etching agent suitable for the particular metal of which the screen is composed.

One very advantageous method of obtaining the 45 desired result is described in my co-pending application Ser. No. 203,503, filed in the United States Patent Office April 22, 1938, for "Process of producing electrolytic foraminous sheet," and it comprises the step of causing to flow through the 50 apertures ferric chloride or other fluid having the property of acting corrosively on the material of which the sheet is composed. This method has the advantage of cutting back the walls of the holes at a greater rate than that at which the 55 thickness of the screen is reduced.

Another process is to subject the skeleton screen anodically to the action of an electrolytic solution of pyro-phosphoric acid and water—for example, two-thirds pyro-phosphoric acid and one-third water. The tank is operated at a potential 60 across the electrodes high enough to dissolve sharp ridges and the roughness of the surface so as to produce a screen which has a high ratio of hole size to land thickness and also to give a 65 marked surface smoothness.

The extent of reduction is considerable, it being preferable that it be carried to an extent approximately as illustrated in Fig. 3, where the broken 70 line 7 shows the outline of the section of the screen 6, while the solid line 8 shows the outline of the section after the reduction has taken place. The amount of reduction is not critical, but it is preferably carried to an extent that will leave 75 only enough stock to permit handling of the

structure without danger of rupture or other injury.

It is desirable in many if not most cases (having in view the ultimate section desired in the finished screen) that the section of the skeleton screen be as nearly circular as possible. I have found that this object may be attained in the electrolytic cutting-back process by treating the screen that comes from the matrix in such manner that the cutting-back effect takes place mainly on the "flat" side of the lands—i. e., the side that was in contact with the matrix. This I have found can be accomplished in the electrolytic process of cutting-back above referred to by directing the "flat" side toward the cathode, whereby the cutting-back of the "flat" side proceeds considerably more rapidly than it does on the curved side. At the same time, the corners are rounded off, and the whole effect is to cause the section to approach a circular contour. On the other hand, a contour departing from the circular may be desired and the contour of the section of the skeleton screen will be varied accordingly. For example, by "cutting back" only to a limited extent the half-round or half-elliptical contour of the section may be wholly or partly preserved and the added material next to be described will take a contour similar to that of the skeleton although circumscribing a larger area.

The next step consists in employing the skeleton screen indicated by the line 8 in Fig. 3 as a cathode in suitable electroplating equipment and adding material thereto to produce the result shown in Fig. 4, which may be assumed to be of the cross-section area and of the cross-section contour which was pre-selected as the form and dimension to be attained. It will be seen from Fig. 4 that the skeleton screen has been built up by the addition of the material 9 so that the dimensions $a-b$ and $c-d$ are very nearly equal to the dimension $b-c$, and the section exhibits very nearly the outline of a circle or at any rate of a figure that is only slightly oblong. It should be explained however that these pre-selected dimensions and contour are merely a matter of the specifications required in the ultimate product and may be varied to suit the requirements of the particular case. The absolute dimensions of the skeleton screen may be taken to be the distance between the centerlines of adjacent parallel lands—i. e., the distance $o-o'$ in Fig. 4. The relative dimensions of land thickness and hole size assuming a given distance between these centerlines may be varied to suit the requirements to be met in a particular case. As the distance $o-b$ increases, the distance $b-c$ decreases, and vice-versa.

It is to be observed that, as the building-up process continues, the section progressively approaches a circle. The larger the section (in absolute measurement) of the skeleton screen, the thicker must be the built-up area of the section to reach a circle, or approximate circle, of a given curvature. It is therefore of distinct advantage, if an approximately circular section is desired in the ultimate product that the section of the skeleton screen be reduced to dimensions that are as small as possible and still permit it to be handled and operated on in an electroplating equipment. Another factor that contributes to the attainment of this object is the fact that, in "cutting back" the screen that is removed from the matrix to form the skeleton screen either by the etching process or the electrolytic process, the

tendency is to cut away the walls of the holes at a greater rate than the faces of the screen. Since the section as taken from the matrix is necessarily elongated, the tendency in the cutting-back step is to produce a section that is fairly symmetrical about its center. On the other hand, in the case of the building-up process, the deposited material increases in thickness substantially uniformly over the entire surface of the section—i. e., not only in the walls of the holes but on the faces of the screen. The section therefore progressively approaches a circle and the smaller the section of the skeleton screen the more rapidly does the section of the added material approach the circular form.

If, however, a non-circular section of predetermined contour be desired, it is necessary that the skeleton screen be of a contour such that, when the added stratum is applied, the result will be a land section contour of the shape and size desired. Since, as has been pointed out, building up on a skeleton screen section of any contour, circular or otherwise, will, provided the section be small enough, result in an ultimate circular section, it is necessary when a non-circular section is desired that the contour of the skeleton screen land section be large enough so that its shape is not "lost" in the building-up process. The general principle involved is that the contour of the skeleton screen land section should be reduced in dimension from the contour ultimately desired by a substantially uniform decrement. This will be clear by an examination of Fig. 4 wherein the distances $e-f$ and $g-d$ indicating the decrement referred to are equal. While the distance $o'-g$ is greater than the distance $o'-c$, the total distances $o'-f$ and $o'-d$ are practically equal—in other words, the outer contour of the section is for all practical purposes a circle. On the other hand, it will be clear that the smaller the decrement in the case of a given outer contour, the less the outer contour departs from the contour shape of the skeleton screen.

To sum up, the combination of the three factors—i. e., the tendency of the "cutting back" step to produce a circular section, the dimension of the skeleton screen section, the contour of the skeleton screen section, and the uniformity and degree of thickness of the added material must all be coordinated to produce a screen of predetermined land section contour.

The added material 9 preferable is not the same as the material of the skeleton screen; on the contrary, it may be a different material, if desired; for example, the skeleton screen may be of copper and the added material either copper or some other material such as nickel. For most purposes where strength, flexibility, and resistance to fatigue are the essentials, nickel is suitable. However, when non-corrosive or other special characteristics are required, the added metal will be chosen accordingly.

It will be obvious that the purpose of the skeleton screen is merely that of a base or framework on which to apply the metal of which the ultimate product is chiefly composed. It is contemplated that the cross-section area of the added material is considerably greater than the cross-section area of the skeleton.

If desired, the built-up product may be subjected to a slight etching which will remove any sharp edges or corners or any projection but which will not substantially reduce the cross-section areas of the lands.

I have described above certain embodiments of

my invention and a preferred process with certain modifications thereof, but I wish it to be understood that these are merely examples and not limitative of my invention and that I include
 5 therein various changes in form and also various changes in processes of manufacture that fall within the spirit and scope of my invention, as set forth in the claims.

I claim:

10 1. A process of producing a foraminous sheet which comprises producing by electrolytic deposition a foraminous sheet structure, reducing the thickness of the sheet and enlarging the holes
 15 by removing by an etching process a stratum of material from the same of a depth sufficient to leave a skeleton screen presenting a smooth surface throughout, substantially free from irregularities of contour, and then adding to the skeleton
 20 screen by electrolytic deposition a stratum of material of a thickness sufficient to build the structure to a predetermined land cross-section area, the area of the added stratum of material at any cross-section of land being greater than that of the skeleton screen at the same section of land.

25 2. A process of producing a foraminous sheet which comprises producing by electrolytic deposition a sheet structure of screen pattern, reducing the thickness of the sheet and enlarging the holes by removing by an etching process a stratum
 30 of material from the same of a depth sufficient to leave a skeleton screen presenting a bright smooth surface throughout, substantially free from irregularities of contour, and then adding to the skeleton screen by electrolytic deposition a
 35 stratum of material of a thickness sufficient to build the structure to a predetermined land cross-section area, the cross-section area of the added stratum of material at any cross-section of land being greater than that of the skeleton screen at the same cross-section of land.

40 3. A process of producing a foraminous sheet which comprises producing by electrolytic deposition copper sheet structure of screen pattern, reducing the thickness of the sheet and enlarging the holes by removing by an etching process
 45 a stratum of material from the same of a depth sufficient to leave a skeleton screen presenting a smooth surface throughout substantially free from irregularities of contour, and then adding to the skeleton screen by electrolytic deposition
 50 a stratum of material other than copper of a thickness sufficient to build the structure to a predetermined land thickness, the cross-section area of the added stratum being greater than that of the skeleton screen.

55 4. A process of producing a foraminous sheet which comprises producing by electrolytic deposi-

tion a copper sheet structure of screen pattern, reducing the thickness of the sheet and enlarging the holes by removing by an etching process a stratum of copper from the same of a depth
 5 sufficient to leave a skeleton screen presenting a bright smooth surface throughout substantially free from irregularities of contour, and then adding to the skeleton screen by electrolytic deposition a stratum of nickel sufficient to build the structure to a predetermined land thickness and hole size, the cross-section area of the stratum of nickel being greater than that of the skeleton screen.

10 5. The process of producing a foraminous sheet of predetermined specifications as to absolute and relative dimensions of hole size and land thickness, which comprises producing by electrolytic deposition a sheet structure of screen pattern, the distance between centerlines of the lands of which pattern is equal to the distance between
 15 the centerlines of the lands of the foraminous sheet to be produced, reducing the thickness of the sheet and enlarging the holes by removing by an etching process a stratum of material from the same of a depth sufficient to leave a skeleton
 20 screen presenting a smooth surface throughout substantially free from irregularities of contour, and then adding to the skeleton screen by electro-deposition an adherent stratum of material of a thickness sufficient to build the structure to the predetermined dimensional relations of hole size and land thickness, the cross-section area of the said adherent stratum being greater than the cross-section area of the skeleton screen.

25 6. The process of producing a foraminous sheet composed chiefly of nickel and of predetermined specifications as to absolute and relative dimensions of hole size and land thickness, which comprises producing by electrolytic deposition a copper sheet structure of screen pattern the distance
 30 between centerlines of the lands of which pattern is equal to the distance between the centerlines of the lands of the foraminous sheet to be produced, reducing the thickness of the sheet and enlarging the holes by removing by an etching
 35 process a stratum of material from the same of a depth sufficient to leave a skeleton screen presenting a surface that is smooth throughout and substantially free from irregularities of contour, and then adding to the skeleton screen by electrodeposition an adherent stratum of nickel
 40 of a thickness sufficient to build the structure to the predetermined dimensional relations of hole size and land thickness, the cross-section area of the said adherent stratum of nickel being greater
 45 than the cross-section area of the skeleton screen.

EDWARD O. NORRIS.