

June 23, 1942.

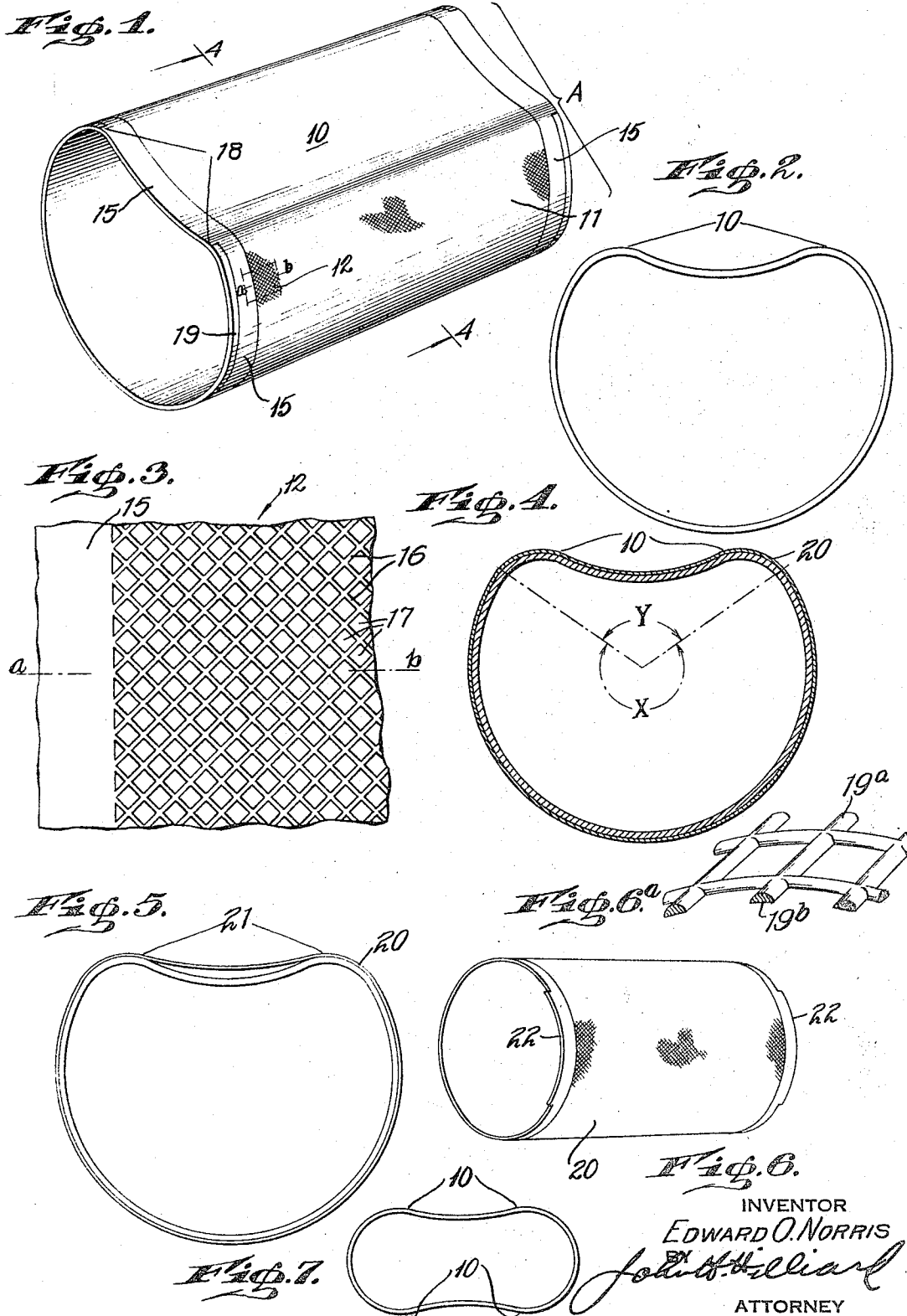
E. O. NORRIS

2,287,122

PROCESS OF PRODUCING ENDLESS FORAMINOUS SHEET-METAL BANDS

Filed Aug. 3, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

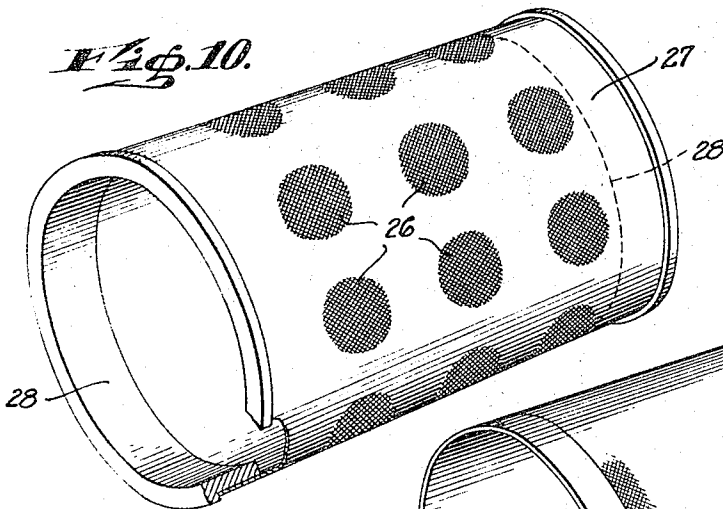
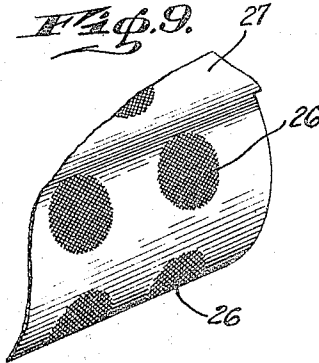
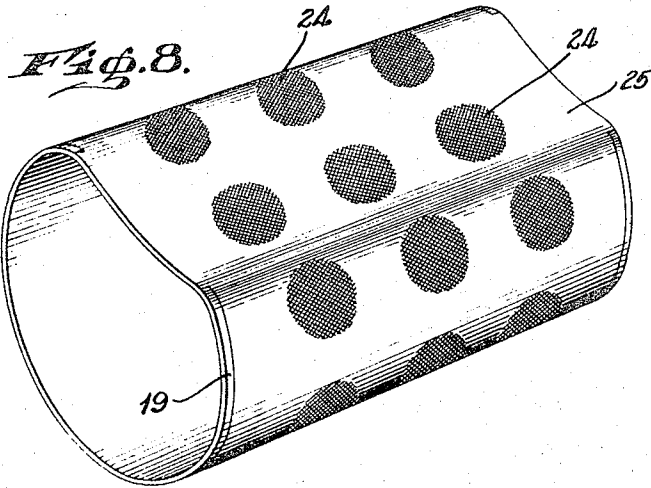


Fig. 11.

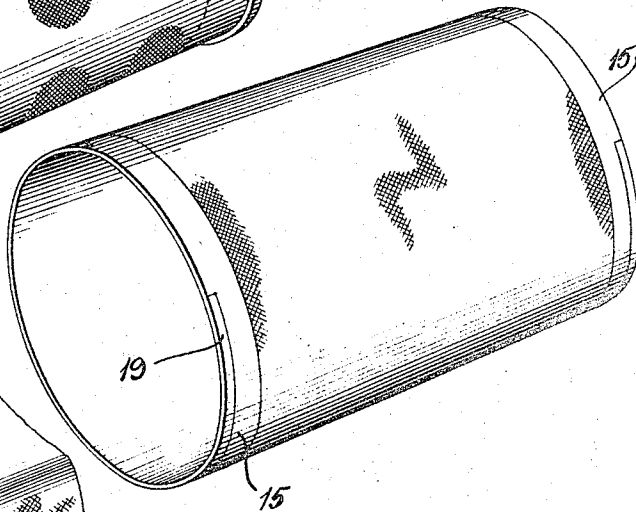
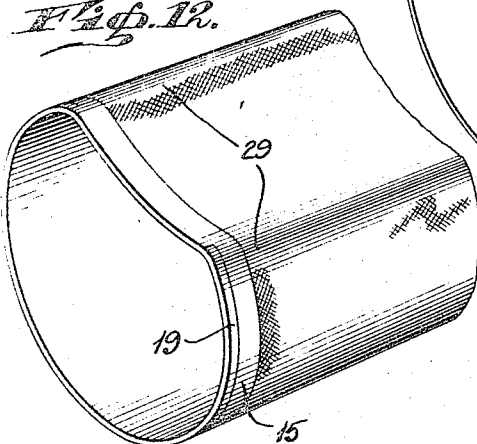


Fig. 12.



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2,287,122

PROCESS OF PRODUCING ENDLESS FORAMINOUS SHEET-METAL BANDS

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7 Claims. (Cl. 204—11)

The invention broadly relates to a process for producing by electroforming endless seamless and jointless foraminous sheet-metal bands. More specifically, it relates to a process of producing thin foraminous sheet-metal bands in the form of hollow seamless and jointless cylinders. To amplify, these bands or cylinders are of thin sheet-metal provided with a great multitude of fine perforations usually symmetrically arranged as in rows and columns, such as are characteristic of material for filtering, stencil printing, separating, and numerous other purposes of related character. When used for stencil printing, they may be used to connect and travel on co-operating pulleys after the manner of endless belts, or they may be used in cylindrical form as rotary stencils, for applying designs in ink, paint, glue, dye or the like to fabric and other material or for completely coating them. For the sake of brevity the foraminous sheet may be termed "screen" regardless of the actual use to which it may be put.

To explain what I mean by "thin" sheet-metal, the material of the band or cylinder would not often exceed .015" in thickness and in most cases would be much less—say .010" or under. The mesh of the screen would seldom be less than twenty perforations per linear inch and in most cases would be greater—say forty or more, and the area of opening would for most purposes be adjusted with respect to the land width so as to obtain a maximum total area of opening consistent with the desired strength. As will be seen later, the process as actually practiced in producing bands or cylinders for stencil printing or coating purposes results in a product that is characterized by a very efficient flushing face—i. e., the surface of the band or cylinder which contacts with the fabric or other material is so designed as to result in a most effective spreading of the ink, glue, or other substance that is being applied. It will be obvious as the explanation continues that this feature is of great advantage in printing colored fabrics, in flock-printing, and the like in order that solid blocks of color may be produced.

Another advantage as contrasted with present-day methods of producing stenciling cylinders is that the perforations are square instead of round, and thus a maximum area of opening consistent with strength becomes possible, thus still further assisting in the complete covering of the design areas. Again, the cylinder, or band as the case may be, is seamless and jointless and thus the weakness arising out of the

presence of seams and joints in material of this sort is absent. The process is further particularly advantageous, because the matrices on which cylinders and bands such as I have referred to are electroformed, will stand very little, if any, distortion or rough treatment. They are necessarily expensive to make and accordingly should, from the standpoint of economy, be capable of being used over and over again.

Another important object is a method of removing electroformed deposits from the peripheries of cylinders and bodies of similar shapes like those having polygonal, elliptical and other non-round sections.

Referring to the drawings,

Fig. 1 is a perspective view of a matrix suitable for the reception of an electroformed screen deposit on its outer periphery;

Fig. 2 is an end view (not in perspective) of Fig. 1;

Fig. 3 is a detailed view of the cathode surface of the matrix;

Fig. 4 is a view in transverse section (not in perspective) on the line 4—4 of Fig. 1 and showing, in addition, a screen deposit on the outer periphery thereof;

Fig. 5 illustrates how the electroformed screen band, or cylinder, is removed from the matrix;

Fig. 6 shows the screen after it has been removed from the matrix and formed to the shape of a true hollow cylinder;

Fig. 6a is a perspective view very much enlarged of a small portion of the outer periphery of the cylinder of Fig. 6;

Fig. 7 shows diagrammatically an end view of a modified shape of matrix;

Fig. 8 shows, in perspective, a modified cylinder matrix adapted for electroforming a stencil exhibiting a conventional design of a multitude of circular areas;

Fig. 9 shows a broken view of a portion of the matrix of Fig. 8 with an electroformed screen cylinder that has been deposited thereon;

Fig. 10 is a perspective view of the stencil of Fig. 9 after it has been removed from the matrix of Fig. 8, formed to a true cylinder and reinforced at its ends;

Figs. 11 and 12 are intended to show a modified process, Fig. 11 showing a matrix of true cylindrical form and Fig. 12 showing the same matrix after it has been deformed to permit of the removal of an electroformed screen deposit.

Referring to Fig. 1, the preferred type of matrix and the type that I find lends itself most readily to my process is a hollow form designated

as a whole by the letter "A", the periphery of which is of cylindrical cross-section through the greater part of a circle about its axis as shown in Figs 2 and 4. The angle subtended by the circular part is not at all critical, but I find that 270°—or roughly three-fourths of a circle—is quite suitable, as shown by the angle X in Fig. 4. The remaining portion of the section is re-entrant toward the axis of the cylinder on a gentle double reverse curve as is shown, subtended by the angle Y, Fig. 4, thus forming a shallow groove or re-entrant area 10 running the entire length of the form. While I have stated that the matrix (the shape of which I will describe as that of a modified cylinder) is hollow, that is only by way of preference, since so far as the electroforming step (hereinafter described) is concerned, it may be solid. However, from practical considerations, such as weight, convenience of handling, cost, etc., it is preferable that it be hollow, although the walls should, of course, be rigid and strong enough to withstand the handling necessary in carrying out the electroforming step, as will be presently described.

The method of making the matrix of Fig. 1 is not a part of my invention except insofar as its shape is concerned. However, I will briefly describe one way in which the cathode surface 11 composed of the peripheral area of screen pattern may be produced, and will refer to United States Letters Patent No. 2,166,366 of July 18, 1939, and No. 2,231,678 of February 11, 1941, and my co-pending applications for patents, Ser. Nos. 298,215 filed October 6, 1939, and 298,216 filed October 6, 1939, all of which show methods of producing a matrix in sheet form, the cathode area of which exhibits a screen pattern delimited by electrically insulated areas.

To briefly describe a simple but practical method, a sheet of copper is covered with a film of emulsion, comprising for example photographer's glue, and rendered light-sensitive by adding to the glue any one of numerous well-known materials adapted for this purpose. The negative of a crossed-line half-tone screen the lines of which are opaque is then photographically printed on the film, and the sheet is then "developed." The developing process results in washing away the minute square areas, or "dots," of the emulsion that have not been affected by the light projected through the negative, thus baring the metal of the sheet where the washing has been effective. The metal is then etched (e. g., if of copper, by ferric-chloride) which produces concavities where the areas or "dots" of bared metal are located. The hardened emulsion remaining which defines a screen pattern is then removed by scraping, dissolving with caustic potash or otherwise, and the flat sheet thus made is formed into a cylinder with the concavities opening to the outer periphery, and the edges after having been carefully trimmed so that the pattern is not broken are joined together by soldering or welding. The re-entrant area is then formed by bending the sheet inwardly so that it takes the form in cross-section shown in Fig. 2. Thereupon the concavities are filled with electrically insulating material, such as Bakelite or other plastic, varnish, shellac, or asphaltum, or a number of other electrically insulating materials that are capable of withstanding the treatment to which the matrix is subjected in the electroforming step. As a specific example, Bakelite serves the purpose excellently well. If necessary or desired, the mod-

ified cathode cylinder A may be stiffened and made more rugged by supporting it on a form provided with a re-entrant area to conform to the interior shape of the modified cylinder.

For certain purposes (e. g., where the screen cylinder to be formed on the matrix is to be used as a rotary stencil for printing on or coating fabric or the like) it is desirable that the lands be arranged helically about the axis. A forty-five degree helix is quite satisfactory as shown in the drawings. The purpose is to avoid as far as possible the so-called "moiré" effect when the electroformed cylinder is employed as a stencil for printing on woven fabric such as in color-printing or applying a binder for the application of flock. To make this clear should be explained that even though the lands be parallel with the axis of the stencil, it seldom happens that they are exactly parallel with the weft threads of fabric on which the printing or coating is done; in fact, they are almost invariably slightly but noticeably out of parallelism with the weft threads. This condition results in a maximum moiré effect, which, however, is very much reduced by the helical arrangement to which I have just referred. The deposit-receiving bands of the matrix are arranged in a corresponding helix which merely means that in the original photo-printing on the copper plate from which the matrix is made, the lines of the half-tone screen are properly oriented to produce this result.

The foregoing will be clear by an examination of Fig. 3 which is a very greatly enlarged view of a small area 12 of the matrix of Fig. 1, the reference lines *a-b* in Fig. 3 and *a-b* in Fig. 1 being assumed to be coincident. The area 15 shows the margin solid throughout; the lines or bands 16 show the metallic areas which take the electroformed deposit; and the areas 17 show the insulation from which the perforations in the stencil result. It will be observed that the deposit-receiving lines or bands 16 are diagonal to the line *a-b* at approximately 45°.

It is preferably that in the case of the matrix of Fig. 1, there be a marginal zone 18 of metal unbroken by the small insulated areas so that, when an electroformed deposit is laid thereon, it will have a solid selvage edge for strengthening purposes. This unbroken marginal zone may however be insulated at its extreme edge as indicated at 19 for purposes to be hereafter explained.

In carrying out the electroforming step on the matrix of Fig. 1, the outer surface is first coated with a thin stripping film which may be produced by the application of wax highly diluted with a solvent, such as carbon tetrachloride. After drying, the surface is capable of receiving an electroformed deposit which, however, is adherent only to a very slight degree to the wax and not at all to the metal.

Regardless, however, of the tenacity of adherence or lack of it, there is very great difficulty in removing the deposit from endless surfaces such as the peripheries of bodies of circular, elliptical, polygonal, or other sections of closed form. To take a specific example, the difficulty becomes readily apparent if it be attempted to strip a deposit from the periphery of a cylinder. The difficulty is especially pronounced in the case of many metals by reason of the fact that, when electroformed, they are in a state of tension in all directions, and obviously this tension must be relieved before the deposit can be

stripped from bodies of the characteristics as to form above-described. The phenomenon is particularly noticeable in the case of nickel which, as happens, is especially useful for the purpose for which the invention is usually employed. The re-entrant area of the matrix is utilized as a means of making possible the removal therefrom of the electroformed stencil.

After waxing, the matrix is ready for the electroforming process. This involves merely employing it as a cathode in an electrolytic plating system according to conventional methods and causing a metal deposit of the required depth to be electroformed thereon. The deposit may, it goes without saying, be of any metal that can be electrolytically deposited, such as copper, nickel, gold or silver. For most purposes I employ nickel since it is electroformed with comparatively little difficulty, and the result is a tough and durable product. In order that the deposit may be of uniform thickness over the entire matrix, it is well to observe the usual precautions as to proximity and shape of anodes that are well understood in the electroplating art.

After the deposit 20 has reached the required depth, but while the perforations are still open, the matrix is removed from the plating tank and it is then ready for stripping. The insulation 19 near the ends of the matrix is best omitted on that portion 18 of the margin which extends across the re-entrant portion as shown in the drawings. In the re-entrant portion therefore the deposit extends to the very edges of the matrix. This fact makes it possible to detach the screen at the ends of the re-entrant areas by first filing away or otherwise cutting the edge to a slight depth and then inserting a knife or similar tool beneath the screen and, by prying and working if necessary, gradually to detach it along the entire length of the re-entrant portion. As a matter of fact, after being slightly loosened near the end, the tension alone is, in most cases, sufficient to lift the screen free from the surface of the re-entrant portion. Thereupon it can be worked with the hands or with a flat rod until it is free entirely around the matrix and is loose enough to be slipped off. The reason, of course, is that, when the deposit is detached from the re-entrant area of the matrix, there results a slack and consequently a release of the tension which has already been referred to, and which is particularly pronounced in the case of nickel. (See Fig. 5, reference figure 2f.) After the electroformed section has been slipped off the matrix, it can be formed by rolling or manipulation to a generally cylindrical form or a number of other forms as may be desired or it can be left as it is and used as an endless band for connecting and operating pulleys.

The step of accurately bringing and setting the electroformed deposit permanently to the shape of a true cylinder (as shown in Figure 6) after removal from the matrix involves however some little difficulty. One method that I have followed with success in accomplishing this purpose is as follows: The electroformed stencil is built up on the matrix say to a thickness of .004 or .005 of an inch. After removal it is stiffened by inserting a closely fitting circular ring within the inner periphery at each end. These rings support the stencil at its end regions and to some extent in the regions intermediate the ends although not wholly so. The reinforced stencil is then deplated anodically in an electrolytic plating system until it has been reduced—say to a thick-

ness of approximately .003". At the same time and as a consequence of the same deplating operation the holes are enlarged, and the entire surface including the walls of the holes rendered very active to electrolytic deposition. In the case of nickel the deplating could be accomplished by carrying it out in a 25% sulphuric acid bath.

The stencil is then mounted so that it can be wholly immersed as a cathode in a nickel plating solution (if nickel has been employed) and rotated at a speed sufficiently high so that the centrifugal force thereby generated is great enough to evenly distend the stencil until it assumes the form of a true cylinder. The centrifugal force is presumably derived chiefly from the mass of liquid inside the rotating stencil and which is dragged around with it by frictional effect. At any rate those portions of the liquid mass in proximity to the inner periphery of the stencil operate in this way, the magnitude of the effect of course decreasing as the axis of rotation is approached. At the same time the stencil is being built up by additional metal deposited thereupon, this continuing until the thickness reaches the desired amount but being limited by the necessity of leaving the holes sufficiently open so that the stencil will properly function as such. The fact that this deposit is being applied while the initial cylinder is in a distended form, that is, in the form of a true cylinder, results in its being permanently set to that form after the operation is completed.

One thing to which I would call attention is that in rotating the initial cylinder continuously in one direction the tendency is to distort the holes so that the axes of the holes are oblique to the surface of the cylinder. This difficulty can be avoided by reversing the direction of rotation from time to time.

The screen made by the method which I have just described or by the method described in my United States Patent No. 2,166,366 has a special value for use in stencil printing with paint, ink, glue (flock-printing), or the like, by reason of the fact, as may be observed from Fig. 6a, that the lands are approximately half-round in cross-section, the half-round faces 19a being exposed on the exterior periphery of the stencil and the flat faces 19b being exposed on the interior. The half-round shape of land section results in a very reduced area of contact between the lands and the contacting fabric, and therefore the ink, glue, paint or other substance being applied flushes freely, covering the fabric completely or so nearly completely that whatever minute uncovered areas are left are not discernible to the eye; on the other hand, the flat sides of the lands on the interior of the stencil co-operate to the best advantage with a squeegee or doctor-blade, such as is used in present-day rotary stencils for forcing the substance being applied through the perforations and onto the fabric.

Fig. 7 is merely a diagrammatic view in section of another form of matrix than a modified cylinder from which deposits may be stripped in essentially the same manner as in the case of stripping from the matrix of Fig. 1.

Figs. 8, 9, and 10 illustrate how my process may be applied to the production of a stencil adapted for printing on fabric or other surface a design or pattern, as distinguished from an overall coating such as would be produced by the stencil of the previous figures. Fig. 8 shows a matrix exactly similar to the matrix of Fig. 1 with the additional feature however that I have so treated

the cathode surface that the stencil electroformed thereon exhibits a design consisting, for the sake of simple illustration, of rows of disc-shaped areas. These areas are foraminous while the remaining portions are imperforate. In producing the matrix I apply to its surface the desired design (for example, the disc-shaped areas) by first covering the design areas 24 with shellac. I then apply to the entire periphery of the matrix cylinder a very thin coating of wax which is preferably, when applied, dissolved in a volatile solvent such as carbon tetrachloride. On evaporation of the carbon tetrachloride the wax coating becomes dry or at least tacky.

After the wax solvent has evaporated I scrub the periphery of the cylinder with graphite, thus rendering the surface receptive to an electroformed deposit.

The shellac is next completely removed by dissolving and washing with alcohol which penetrates through the thin wax and graphite coating, thus leaving disc-shaped areas 24 of screen pattern, the remaining areas 25 being completely receptive to a non-adherent imperforate electrolytic deposit.

The matrix as thus prepared may be employed as a cathode for the electroforming of a cylindrical stencil or endless band, as illustrated in broken view in Fig. 9. The foraminous areas (that is, the disc-shaped areas) are indicated by the numeral 26 as shown in the figure, and the remaining areas 27 are imperforate. The electroformed stencil (Fig. 9) after being electrodeposited is removed from the matrix of Fig. 8 in the same manner as in the case of the previous figure and is then brought to the shape of a true cylinder in the same manner as the stencil made on the matrix of Fig. 1. The electroformed stencil of Fig. 9 is preferably stiffened by internal reinforcing rings 28 and it is then ready to be mounted in a conventional machine for coating preparatory to the application of flock or for printing or like processes in which it is desired to apply to a surface a design in ink, paint, glue, or the like, conforming to the disc-shaped foraminous areas 26 of the stencil.

In Figs. 11 and 12 I illustrate a second method of removing the electroformed stencil (in this case foraminous throughout) from the matrix. Fig. 11 illustrates a matrix that is truly cylindrical. After a stencil has been electroformed thereon the matrix with the stencil still on it is given a re-entrant shape as indicated by 29 in Fig. 12. This being done the electroformed stencil becomes slack and may be worked off in the same manner as shown in Fig. 5. No further treatment is necessary unless it be desired to alter its cross-section shape.

I have described above certain embodiments of my invention, but I wish it to be understood that these are illustrative and not limitative and that I reserve the right to make various changes in form, construction, and arrangement of parts that still fall within the spirit and scope of my invention as set forth in the claims.

I claim:

1. The process of producing seamless and jointless endless bands of sheet-metal, which comprises electroforming the sheet on a matrix having an exterior endless deposit-receiving surface a part of which surface comprises a re-entrant area extending the entire width of said surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt

edges are presented, then detaching the deposit from the re-entrant area and then detaching the deposit from the remaining portion of the surface and slipping the electroformed deposit from the matrix.

2. The process of producing seamless and jointless hollow cylinders of foraminous sheet-metal for use as rotary stencils, which comprises electroforming the sheet on the exterior of a matrix having an endless peripheral deposit-receiving surface a part of which comprises a re-entrant area extending the entire width of said surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, the said deposit-receiving surface exhibiting a screen pattern, then detaching the sheet from the re-entrant area and then detaching it from the remaining portion of the periphery, slipping the sheet from the matrix and forming it to a cylindrical shape.

3. The process of producing seamless and jointless endless bands of sheet metal, which comprises electroforming the sheet on a matrix having an endless peripheral deposit-receiving surface a part of which comprises a re-entrant area extending the entire width of the surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, then detaching the deposit from the re-entrant area, and then detaching the deposit from the remaining portion of the periphery, slipping the electroformed deposit from the matrix, deplating the electroformed deposit until the entire area is rendered smooth and clean, and then electroplating the screen to a predetermined depth.

4. The process of producing seamless and jointless endless bands of foraminous sheet-metal, which comprises electroforming the sheet on a matrix having an endless peripheral deposit-receiving surface of screen pattern a part of which comprises a re-entrant area extending the entire width of the surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, detaching the deposit from the re-entrant area, detaching the deposit from the remaining portion of the periphery, slipping the electroformed deposit from the matrix, deplating the electroformed deposit until the entire area is rendered smooth and clean, electroplating the band while immersed in an electroplating solution and while rotating it on its axis at a speed at which the centrifugal force generated holds it distended to a true cylindrical form, the electroplating being carried to the point where the added metal is sufficiently thick to set the band permanently to a cylindrical form.

5. The process of producing seamless and jointless endless bands of sheet-metal, which comprises electroforming the sheet on a matrix having an endless peripheral deposit-receiving surface, a part of which comprises a re-entrant area extending the entire width of the surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, detaching the deposit from the re-entrant area, detaching the deposit from the remaining portion of the periphery, slipping the electroformed deposit from the matrix, deplating the electroformed deposit until the entire area is

rendered smooth and clean, electroplating the band while immersed in an electroplating solution and while rotating it on its axis at a speed at which the centrifugal force generated holds it distended to a true cylindrical form.

6. The process of producing seamless and jointless hollow cylinders of foraminous sheet-metal, which comprises electroforming the sheet on a matrix having an endless peripheral deposit-receiving surface, a part of which comprises a re-entrant area extending the entire width of the surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, detaching the deposit from the re-entrant area, detaching the deposit from the remaining portion of the periphery, slipping the electroformed deposit from the matrix, electroplating the cylinder while immersed in an electroplating solution and while rotating it on its axis at a speed at which the centrifugal force generated holds it distended to a true cylindrical form.

7. The process of producing seamless and jointless hollow cylinders of foraminous sheet-metal, which comprises electroforming the sheet on a matrix having an endless peripheral deposit-receiving surface, a part of which comprises a re-entrant area extending the entire width of the surface, said re-entrant area merging into the remaining area of said surface gradually and on a continuous curve so that no sharp or abrupt edges are presented, detaching the deposit from the re-entrant area, detaching the deposit from the remaining portion of the periphery, slipping the electroformed deposit from the matrix, electroplating the cylinder while immersed in an electroplating solution and while rotating it on its axis at a speed at which the centrifugal force generated holds it distended to a true cylindrical form, the electroplating being carried to the point where the added metal is sufficiently thick to set the cylinder permanently to a cylindrical form.

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