[54] METHOD TO PREPARE MATRICES TO MANUFACTURE LATTICE OR GRID METAL LAYERS STRUCTURES BY ELECTROLYTIC DEPOSITION

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[57] ABSTRACT
A lattice or grid metal layer is made by providing a matrix carrier in which, contrary to the prior art, the areas to form the solid portions of the lattice are depressed into the matrix body and, thereafter, the depressions are filled in with a metal by electrolytic deposition, from which the grid structure can then be prepared, the regions or zones between the metal fillings, and to form those zones which will be the interstices of the grid or lattice, are covered by electrically non-conductive material. Grinding or polishing steps may also be used to form a uniform, smooth surface from which the grid or lattice structure can be, electrolytically, prepared.

15 Claims, 19 Drawing Figures
METHOD TO PREPARE MATRICES TO MANUFACTURE LATTICE OR GRID METAL LAYERS STRUCTURES BY ELECTROLYTIC DEPOSITION

The present invention relates to a method for the preparation of matrices for the manufacture of lattice or grid metal layer structures having openings therein of predetermined shape and size, by electrolytic deposition.

Grid or lattice structures are usually manufactured by electrolytic deposition; this known method requires a tool, referred to as a matrix. Manufacture of the matrix itself, as well as the matrix structure as such, is an expensive and hence time consuming operation.

It is an object of the present invention to simplify the method of making the matrix from which a lattice structure can be prepared by electrolytic deposition.

Subject matter of the present invention

Briefly, rather than forming depressions in a matrix in accordance with the shape and size of openings of the lattice structure, which requires deformation of the matrix material to a substantial extent, the matrix material is deformed at those regions where the lattice or grid elements are to be placed. The matrix is, therefore deformed in accordance with the grid or lattice network, the deformations are then filled with electrically conductive material and a known electrolytic process may then be utilized to prepare the grid or lattice structure therefrom.

The invention will be described by way of example with reference to the accompanying drawings, wherein:

FIGS. 1–3a are schematic representations of sequential steps in a formation of a matrix in accordance with the prior art in which FIG. 1 is a schematic top view of a matrix; FIG. 2 is a cross-sectional view along lines II–II of FIG. 1; FIG. 3 is a cross-sectional view through the upper surface of the embossed matrix; and FIG. 3a is a cross-sectional view through a negative of an embossed matrix;

FIGS. 4–9 are sequential cross-sectional views of a matrix body, illustrating sequential steps in the formation of the matrix in accordance with the present invention;

FIGS. 10–14 are cross-sectional views of a matrix body showing sequential steps in accordance with another embodiment of the present invention; and

FIGS. 15–18 are cross-sectional views similar to FIGS. 4–9 in accordance with yet another embodiment of the invention.

The method, in accordance with the prior art, to manufacture matrices is illustrated in general in FIGS. 1–3. A base body, typically a metal cylinder is the initial structure. The base body has, on its surface, a layer of suitable thickness made of a material which can be embossed. Such a material may be copper, brass, or even soft steel. The surface of the material is made smooth, for example by grinding or polishing, rolling, or by electrolytic polishing.

The base body, illustrated generally at 4 (FIG. 3) has a pattern of a predetermined shape embossed therein. This pattern corresponds to the structure of the lattice or grid network to be made by the matrix. The embossing step is carried out by a so-called relief or embossing element 1 (FIGS. 1, 2). This embossing die is a small, hardened steel cylinder on which the pattern to be embossed is formed, the embossing pattern being a negative of the pattern to be embossed in the matrix body 4. The relief 1 is made by engraving, or similar technology. The elements of the embossing pattern, usually, consist of projecting cones 2, having hexagonal base surfaces, separated from each other by grooves 3. The cones 2 are offset with respect to each other, in honeycomb fashion, as best seen in FIG. 1. The surface to be formed thereby will be seamless. Upon embossing, the matrix body 4 will have ribs 3' and depressions 2' (FIG. 3) formed therein, which correspond to the embossed projections 2 and grooves 3, respectively, of the embossing die illustrated in FIGS. 1 and 2.

Upon pressing the die 1 by means of a suitable machine, similarly, for example, to a lathe, into the relatively softer surface of the base body 4, a negative impression of the surface structure of the die 1 is obtained in the surface of the base body 4. This negative structure is seen, in cross section, in FIG. 3, which is the negative of the cross-section seen in FIG. 2. This impression or embossing step is done by rotating the cylinder on which the projecting cone surfaces 2 are located over the base plate 4. FIGS. 1 and 2 illustrate the surface in developed form. The pattern which is transferred to the base body 4 is seamless. A plain base plate 4 is fed in synchronism with the embossing die, so that the circumferential speed of the embossing die 1 and the linear surface speed of the plate 4 are identical. Thus, for each revolution of the embossing die 1, base plate 4 is fed longitudinally by a similar distance as the circumferential extent of the embossing die, so that one or more elementary areas 2 are passed over the base plate 4 at the same rate. The embossing die 1 and the base plate 4 are thus interengaged similar to a tooth-and-detent arrangement, as in gearing, or in screws, so that, after synchronized embossing feed movement has commenced, the synchronism will be automatically and inherently maintained. This embossing or ruling operation may be carried out in several passes in order to obtain the requisite embossing depth; after one or more passes through a ruling machine carrying out such a sequence of operations, a finished base matrix 4 has been obtained.

The depressed portions 2' of the base body 4 are cleaned, and then filled with an electrically non-conductive material, for example a lacquer, or suitable resin. Usually, the embossed surface is entirely covered with the lacquer, which is then removed, for example by grinding or polishing, to the extent that the projecting portions 3' of the base body 4 are again uncovered. Essentially, the base body 4 is thus finished and, the depressions 2' being filled with non-conductive, insulating material, this base body is now referred to as a matrix or, when circular, as a matrix roller.

The matrix is then placed into a galvanic bath, preferably a nickel bath, and coated galvanically. Those portions of the matrix, which are exposed to the bath, will have nickel deposited thereon. This deposition will, of course, in accordance with the pattern of the projections 3', be in lattice or mesh or sieve-like form.

Galvanic deposition is carried out for a suitable time until a sufficiently thick layer of electrically deposited metal, typically nickel, has been obtained. The nickel plating is then interrupted and the resulting, perforated skin of nickel can be stripped off the matrix by means of a suitable stripping device. A seamless, completely
The sequence of steps to obtain the nickel lattice or grid structure, as described, and in accordance with the prior art, has several disadvantages; the most serious one of these disadvantages is that it is difficult to provide large depressions in the base body. Approximately two-thirds of the surface of the base body must be formed with depressions, the projections forming the remainder and a smaller proportion of the surface of the base body. To obtain such large depressions, the compressive force exerted on the base body is high. Thus, the ruling, or embossing machine, must be capable of transmitting substantial forces, must therefore be heavy and very sturdy, and the base body itself must be made of highly stable and strong materials. This then leads to high weights of the matrix which heavy matrices must be handled in the nickel bath, thus substantially increasing the cost of the entire process.

It is an object of the present invention to simplify this process in such a manner that heavy matrices need no longer be made while still retaining the advantages of the known process and, additionally, to provide a process which results in final products fully compatible with those made by the processes of the prior art, and permitting use of similar equipment.

One of the great difficulties of the process, in accordance with the prior art, is the high force required to emboss the base body. To permit use of a light-weight base body, and to permit use of material which does not have such high strength, the method must be so arranged that the embossing pressures are held to a much smaller level than those heretofore thought possible. This, however, can be obtained only by changing the patterning during the embossing step, since the hardeners of the metal to be embossed can be changed only within small limits.

It has been customary, as above explained in connection with FIGS. 1 and 2, to form the embossing die such that projecting cones, or pyramids are formed on the embossing die. The volume of the depression 2', formed in the base body, then will be much greater than the volume of the rib 3' extending in the grooves between the pyramids or cones 2 of die 1.

The embossing forces can, therefore, be reduced only by changing the volumetric relationship of depressions to be formed in the base body with respect to the remaining ribs. In accordance with the present invention, the ribs are embossed into the base body, rather than the depressions. The volume to be displaced during the embossing step is substantially reduced with respect to the volume which must be displaced in a customary process as above explained. Decreasing the displacement volume permits substantial decrease of the embossing forces. A suitable embossing pattern thus can be readily made by using a pattern similar to that of FIG. 1, embossing a master pattern of soft steel with the negative of the pattern illustrated in FIG. 1, and subsequently hardening the surface. The result will be a master die having a cross section illustrated in FIG. 3a, which is the negative of the cross section of FIG. 2, and formed with pyramidal or conical depressions 2', separated by ribs 3'. The depressions 2', if made separately, may have a flat bottom, and need not be hexagonal. The embossing pattern can be made in shapes other than those shown in FIG. 1 and by direct working of a cylinder of soft steel, for example, with subsequent surface hardening.

In accordance with the present invention, the die having a cross section of FIG. 3a is then pressed into a base body 5 (see FIG. 4) to result in a grid or lattice structure formed of depressed grooves 6 surrounded by higher surfaces 7. The depth of the grooves 6, as well as their shape, and the shape of the surrounding edges defining the groove can be controlled by controlling the embossing pressure, as well as the shape and structure of the embossing die itself.

After base body 5 has received the shape of FIG. 4, that is, with the subsequent conductive portions formed as depressions, various subsequent steps can be carried out to form the final matrix. Three examples will be discussed, all resulting in a matrix from which a nickel lattice or patterned sieve, or grid or mesh network can be obtained by galvanic deposition.

First embodiment, with reference to FIGS. 4-9: The base body 5, made in accordance with the present invention by embossing therein a negative pattern of the grid structure to be made is covered with a hard chrome layer by galvanic process. This hard chrome layer 8 is deposited on the flat surface 9 of the base body 5, as well as in the grooves 6, to form chrome strips 10 continuous with a top layer 11 (FIG. 5).

The chrome layer 8 is then removed to such an extent that the surface portions 9 of the base body 5 are free from chrome, that is, the surface layer 11 is removed. Grinding is a suitable process. The chrome filling 10 within the grooves or notches 6 of the surface 9 of the base body 5 will then have the same level as the base body itself (FIG. 6).

The base body, with the chrome strips in the grooves or notches is then placed in an etch bath which is so selected that it attacks only the material of the base body, but not the chrome in the grooves 6 (FIG. 7). The base material is thus removed and leaves depressed portions 12 between the strips formed by the chrome filling 10. These strips will project as ridges from between the depressed portions 12.

A suitable non-conductive material 13 is then applied—see FIG. 8. This non-conductive or insulating material entirely covers the top surface of the base body 5, with the chrome strips 10 therein.

The base body 5 is then subjected to another material removal operation, for example grinding, to remove that portion of the non-conductive material 13 which extends above the chrome strips 10, to result in the structure of FIG. 9, leaving a base body 5, with exposed chrome strips corresponding to the lattice or mesh or grid network to be then made by electric deposition, in accordance with the prior art. The insulating material 13 may, for example, be a suitable insulating lacquer, varnish or resin. The removal operation of excess insulating material 13 is the final operation and the matrix is thus made which is suitable for further manufacture of nickel lattice or grid or mesh structures.

Second embodiment with reference to FIGS. 10-14: The base body 5 prepared in accordance with the present invention to have the depressed grooves therein (FIG. 4) is covered, selectively, with a suitable cover lacquer 14. Such selective covering extends only over the flat surface; this method is known in gravure printing as surface coating, leaving the depressions free of coating material. The object is to obtain a profiled surface in which a lacquer, or similar material covers only
the projecting portions, the depressed portions of the body being, however, free from covering material or lacquer. All the projecting portions 9 of the surface of the base body 5 are covered, therefore, with lacquer 14, as seen in FIG. 10; the grid or mesh depressions 6 are left free from lacquer or other insulating covering material.

The base body of FIG. 10 is then electrolytically nickel-coated or chrome-plated. The result obtained, after nickel or chrome plating is seen, in cross-section, in FIG. 11; the grooves 6 are filled by the plating metal 15; the electrolytically non-conductive portions of the base body 5 will remain free from plating or coating since they have been covered by electrolytically insulating lacquer layer 14.

It is difficult to interrupt the electro-plating just at the precise moment when the height of the metal filling within the grooves 6 has reached the level of the coating 14; it is thus usually preferred to subject the base body 5 to a grinding operation to provide a complete smooth surface extending overall the base body 5, and smoothly connecting the metal strips 15 as well as the insulating layer 14, as seen, for example, in FIG. 14.

Some lacquers used in selective inking, or selective surface application to cover only the exposed surface are suitable only for restricted use in galvanizing processes, for example nickel or chrome plating, or other plating processes, used in the manufacture of matrices. For frequent use to make the final nickel grid or lattice or mesh structure, the coating 14 may not be sufficiently chemically resistant. Particularly, there may be a lack of chemical resistance with respect to nickel electrolytes, if immersed in such baths over extended periods of time or in repeated processes. In an alternative method, therefore, layer 14 is removed after the first chrome plating step, which had resulted in the structure of FIG. 11. The base body 5, with the coating 14 removed, is seen in cross section in FIG. 12, where depressed portions 16 are shown adjacent the projecting nickel grid or mesh or lattice material 15. Such removal may, for example, be by means of chemical solvents. The surface of the matrix is then covered by another lacquer or resin material which has the property of being highly resistant to nickel electrolytes (although it may not be suitable for selective, surface application only) to result in the structure seen in FIG. 13, where the lacquer or resin layer 13 covers both the surface of the base body 5 as well as the exposed surface of the grid material 15. The base body is then subjected to a further material removing step — after drying of the lacquer, or hardening or curing of resin — for example by grinding, so that the excess lacquer material covering the nickel grid structure 15 is removed, to result in the structure seen, in cross section, in FIG. 14, where the top surface of the matrix is smooth overall, and having the exposed surface portions of the hard nickel, or hard chrome grid or lattice structure 15 with the portions coated by insulating material 13 therebetween.

The final material removal step terminates this modification of the second embodiment of the invention, to result in the final matrix which can then be placed, repeatedly, in nickel plating baths in order to make the eventual lattice or mesh or grid structures.

Third embodiment, with reference to FIGS. 15-18: The material of the base body 5, preferably after having been smooth surface worked, ground and, possibly, polished, is uniformly coated with a suitable insulating layer 17 (FIG. 15), respectively 17" for example a lacquer, resin or the like. Thereafter, coating 17, respectively 17" is penetrated, for example cut by the ridge lines of the impression die, to form grooves for example of V-cross section as seen at 18 in FIG. 15. The die ridge lines are preferably formed with knife edges to penetrate through the lacquer and into the material of the base body 5.

The next step in the process is an electrolytic bath, in which nickel or chrome is deposited in the grooves. The electrolytic deposition is terminated at a time when the metallic portion of groove 18 has been filled entirely with metal, and the entire groove 18 has approximately 20-100% of its volume filled by metal 19 (FIG. 16).

Further working or treatment of the base body 5, with metal portions filled in the grooves, can then continue in various ways, similar to previously discussed processes. For example, the surface of the base body 5, prepared to have the aspect of FIG. 16, is worked, for example by grinding, so that a smooth plane surface is obtained extending over the entire base body 5 and formed of portions of insulating material layers 17', interrupted by the metallic portions 19, as best seen in FIG. 18. This surface working operation completes the production of the matrix.

Alternatively, the coated base body, with the grooves filled by metal 19, and as illustrated in FIG. 16, is treated in a bath in which the lacquer coating 17 is dissolved, leaving depressed portions 20 between which the chrome ridges 19 extend, as seen in FIG. 17. Thereafter, the surface of the base body 5 is coated with an electrolytically non-conductive material, for example lacquer 17 or a resin or lacquer highly resistant to the electrolytic bath which is used to make the final mesh, grid or lattice structure, similarly to the steps explained in connection with FIGS. 12, 13 and 14. Surface 20 is coated with such a lacquer 17, or resin, and the surface is then worked to result in a smooth overall surface as again shown in FIG. 18.

The matrix prepared in accordance with the present invention, and as described in connection with various embodiments thereof, can be used to make all types of sieves or mesh or lattice structures, such as filters, sieve patterns, particularly mesh structures in which the mesh openings must have accurate size and shape, for example as used in screen printing.

Various changes and modifications may be made in accordance with the inventive concept and method steps explained in connection with any one of the embodiments, and described in connection with any one of the Figures as shown may be used, suitably, with other embodiments within the scope of the invention.

A wide range of materials are suitable for use in the processes of the present invention; the particular types of materials used are well known in the art and no specific or special materials need be employed. As an example, the material of layer 8 may be:

- chromium, nickel
- the filling material 10, 15, 19, to fill the grooves typically is nickel or chromium
- the material for selectively insulating the surface layer, see material 14 of FIGS. 10, 11, may be: galvanoresin prepared by asphalt, colophony, bees-
wax; see e.g. H. G. Jakob and F. Weissgerber, Walzengravur und Schablomenherstellung im Textildrucke, 1960 Melliand Verlag
the coating material 13, 17' (FIGS. 13, 14, 18) may be: Araldit A65 106 and hardener HVg53u or Teflon S
material 17 (FIGS. 15, 16) may be, for example: material 14
the base material 5 for the matrix typically is copper, brass, soft bronze, soft steel.

I claim:
1. In a method to prepare matrices for the manufacture of lattice or grid or mesh metal layer structures, having openings of predetermined shape and size, including the steps of
   forming a base body (5) with a surface having electrically conductive portions, in accordance with the solid portions of the grid or mesh structure, and electrically non-conductive portions in accordance with the interstitial openings between the solid portions of the grid and mesh structure, electrolytically depositing a metal layer on the conductive portions, and then removing said metal layer, the improvement wherein
   the base body is of electrically conductive material; and the step of forming said base body (5) comprises the steps of
   forming depressions (6, 18) in the surface of the body (5) having a shape, size and surface distribution corresponding to the electrically conductive portions of the surface of the body by penetrating into the material of the base body (5);
   substantially completely filling said depressions with electrically conductive filler material (10, 15, 19);
   removing a portion of the material adjacent the filled depressions to form depressed portions (12, 16, 20) adjacent the filler material (10, 15, 19), which filler material will form projecting ridges;
   filling the depressed portions (12, 16, 20), between said ridges (10, 15, 19), and corresponding to the electrically non-conductive portions with a layer of insulating material (13, 17) extending between the electrically conductive ridges of filler material filling said depressions;
   and smoothly working the surface of the body with said ridges and insulating material therebetween after said last filling step to provide a uniform, substantially smooth overall surface.
2. Method according to claim 1, wherein the step of forming the depressions comprises embossing a metallic base body (5) with grooves.
3. Method according to claim 1, wherein the step of forming said base body (5) comprises the steps of galvanically applying (FIG. 5) a metal layer (8) to the entire surface of the base body (5) after the depressions have been formed therein;
   removing (FIG. 6) the metal layer from those surface portions of the base body which do not have depressions formed therein to leave a smooth overall surface on the base body formed partly of metal (10) of said layer and partly of the exposed material (9) of the base body;
   wherein the step of removing a portion of the material adjacent the filled depressions comprises removing additional base body material by etching;
the step of filling the depressed portions comprises covering the entire surface of the base body (5) with a covering of non-conductive material (13), and removing (FIG. 9) so much of said covering of non-conductive material to expose the metal ridges (10) filling the depressions and to provide a smooth overall surface.
4. Method according to claim 3, wherein at least one of the removal steps comprises grinding.
5. Method according to claim 1, wherein the step of forming said base body (5) comprises selectively covering (FIG. 10) with an insulating material (14) those portions of the surface of the body (5) which correspond to the electrically non-conductive portions after the depressions (6) have been formed in said base body (5), leaving said depressions free from said insulating covering material (14);
   the step of filling said depressions comprises electro-galvanically over-filling said depressions (6) with metal (15) to form a surface comprising partly metallic ridge portions filling the depressions and partly insulating portions;
   the step of removing a portion of the material adjacent the over-filled depressions comprises removing the insulating material (114) covering;
   and the step of filling the depressed portions comprises filling the surface portions from which the insulating material (14) has been removed with an insulating layer (13).
6. Method according to claim 1, wherein the step of filling the surface portions with an insulating layer (13, 17') comprises the step of coating the entire surface of the base body (5) with said layer;
   and the smooth working step comprises removing so much of said insulating layer to expose the material (10, 15, 19) filling the depressions to provide a smooth overall surface.
7. Method according to claim 5, wherein the covering of insulating material (14) comprises a material suitable for selective application over the surface and without penetration into the depressions (6) formed in the base body (5);
   and wherein the insulating layer (13) comprises a material highly resistant to electrolytic baths used in the step of electrolytically depositing a metal layer over said conducting portions.
8. Method according to claim 1, wherein the step of forming said base body comprises
   covering the entire surface of the body (5) with a layer of insulating material (17) before the surface of the base body is deformed with said depressions;
   the step of forming the depressions comprises forming the depressions in the base body by penetrating the layer of insulating material (17) and into the material of the base body;
   the step of filling said depressions comprises galvanically over-filling said depressions in the base body material with electrically conductive material (19) to form said ridges;
   the step of removing a portion of the material adjacent the over-filled depressions comprises removing the insulating material (17) covering;
   and the step of filling the depressed portions comprises filling the surface portions from which the insulating material (17) has been removed with a non-conductive layer (17').
9. Method according to claim 8, wherein the step of forming the depressions in the base body (5) by penetrating the layer of non-conductive material (17) and into the material of the base body (5) comprises cutting through the layer of insulating material (17) and into the material of the base body (5) with a knife edge tool.

10. Method according to claim 1, wherein the smooth working step comprises grinding.

11. In a method to prepare matrices for the manufacture of lattice or grid or mesh metal layer structures having openings of predetermined shape and size, including the steps of:

- forming a base body (5) with a surface having electrically conductive portions, in accordance with the solid portions of the grid or mesh structure and electrically non-conductive portions in accordance with the interstitial openings between the solid portions of the grid and mesh structure, electrolytically depositing a metal layer on the conductive portions, and then removing said metal layer,
- the improvement wherein the base body is of electrically conductive material; and the step of forming said base body (5) comprises the steps of covering the entire surface of the base body (5) with a layer of non-conductive material (17);

12. Method according to claim 11, wherein the step of galvanically filling said depressions comprises filling said depressions to an extent greater than finally required;

13. Method according to claim 11, wherein the step of covering the surface of the base body (5) with said layer of non-conductive material comprises covering the surface of the base body after the deformation and penetration step with a material suitable for selective application over the surface thereof and without penetration into the depressions formed in the base body (5).

14. Method according to claim 11, wherein said step of covering the surface of the base body with a layer of non-conductive material is carried out before said step of forming said depressions.

15. Method according to claim 14, wherein the step of forming the depressions comprises penetrating the layer of non-conductive material (17) and penetrating into the base body by cutting through the layer of insulating material (17) and into the material of the base body with a knife edge tool.

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