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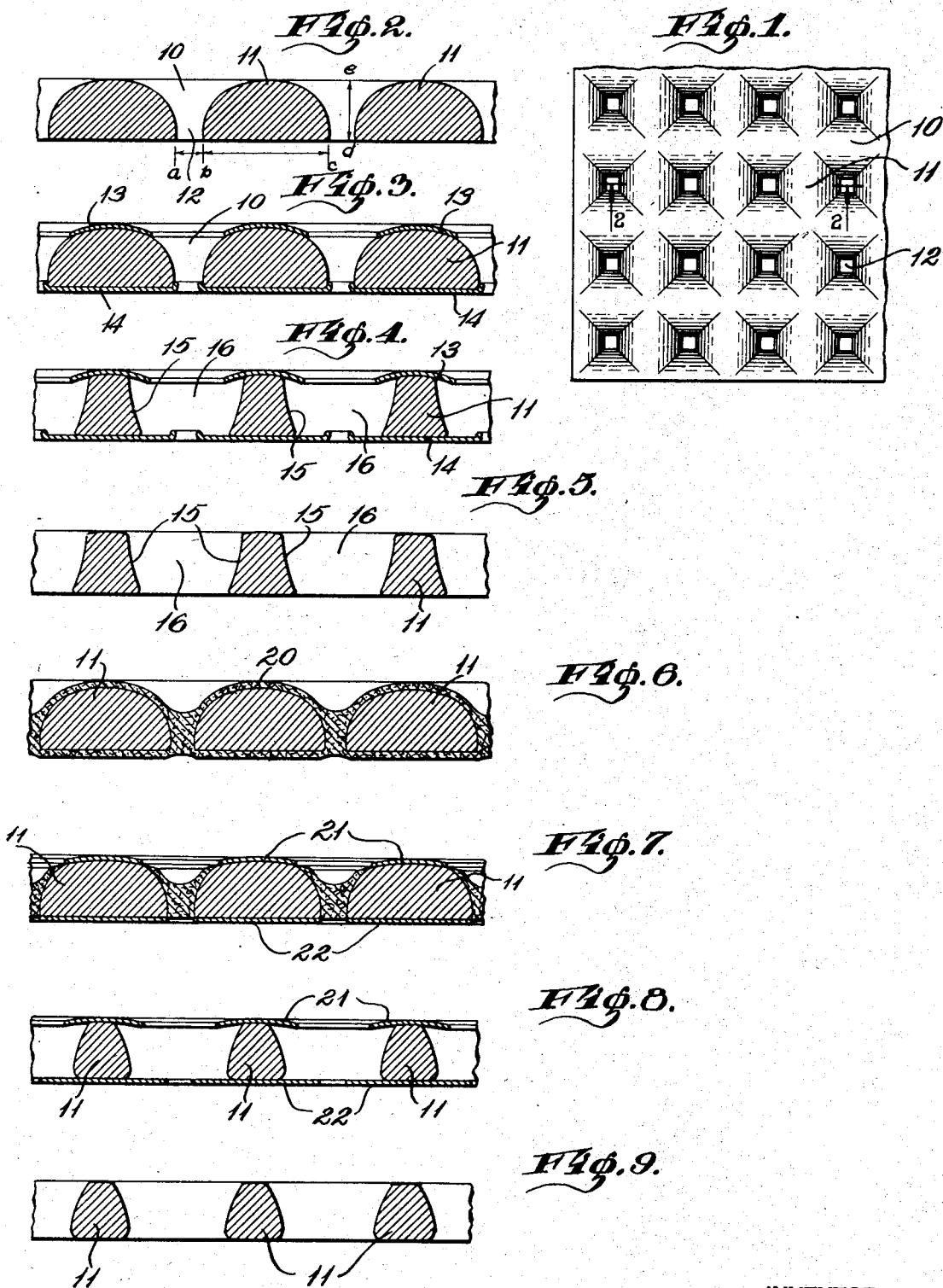
E. O. NORRIS

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PROCESS OF PRODUCING FORAMINOUS SHEETS

Filed Aug. 31, 1938

2 Sheets-Sheet 1



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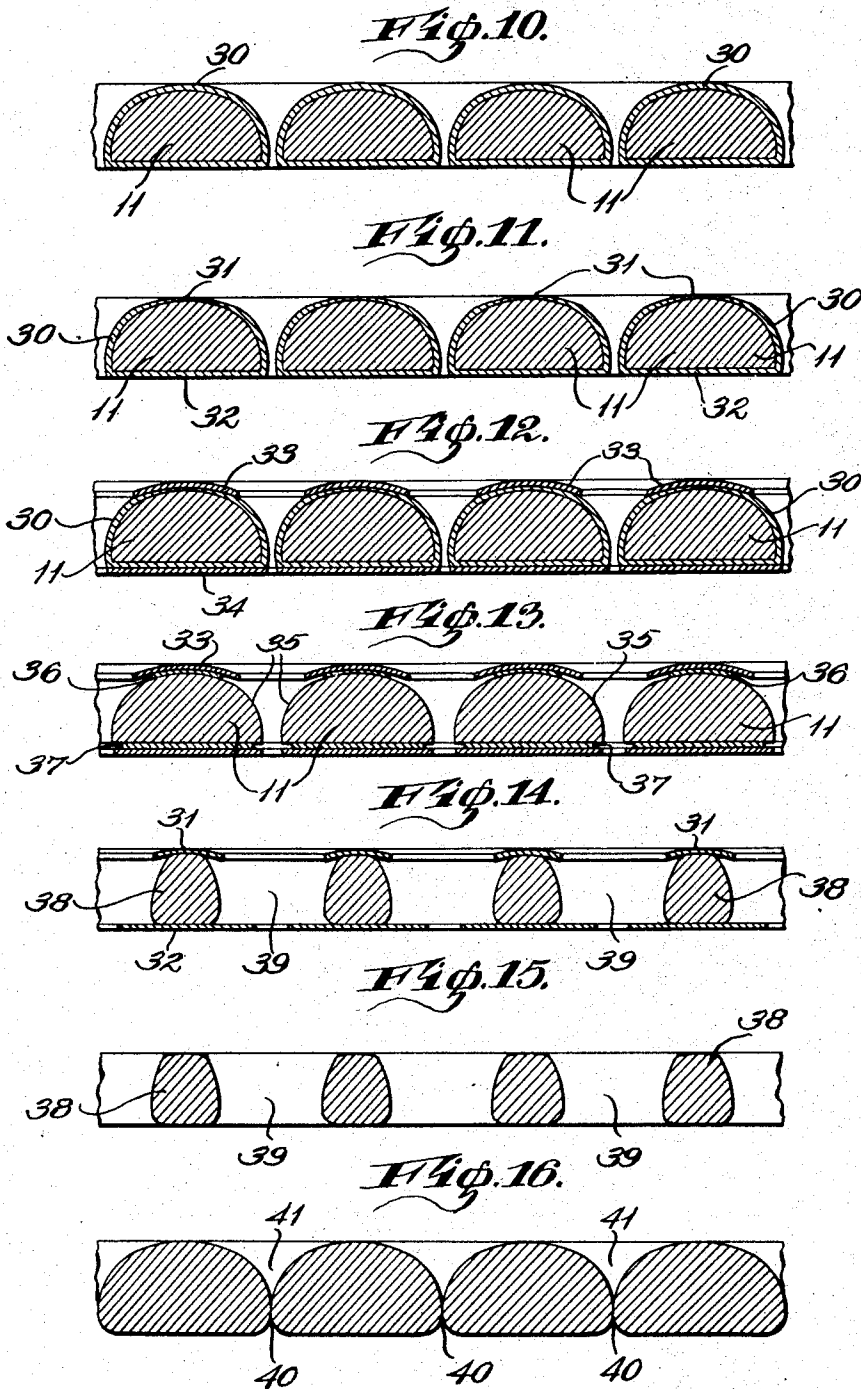
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PROCESS OF PRODUCING FORAMINOUS SHEETS

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11 Claims. (Cl. 204—11)

The invention relates to processes of producing foraminous sheet and is characterized by the fact that it produces a sheet the thickness of which is comparatively great as compared with the size of the perforations. By way of more detailed explanation, attention is directed to my United States Patent No. 2,166,367, issued July 18, 1939. In that patent I describe a matrix for the electrodeposition of screen or other foraminous sheet, the characteristics of the matrix being a depositing surface exhibiting a screen pattern and insulated surfaces of Bakelite or other material having properties similar thereto so far as resistance to receiving an electrolytic deposit is concerned. The exposed surfaces of the insulated areas of such a matrix are flush, or nearly so, with the deposit receiving areas. Foraminous sheet electrolytically deposited on and removed from such matrix is quite satisfactory if only a limited thickness is required. However, the thickness to which the deposit may be built is limited by the fact that, as the electrolytic deposition is continued, the deposit creeps over the insulated areas and the perforations or holes in the deposit become smaller and smaller and, if the process is continued long enough, gradually close up entirely. Of course, the process may be arrested at any stage and, as stated above in effect, the product will serve many useful purposes. More frequently however foraminous sheet (which for convenience may be termed "screen") is desired, in which large perforations exist, coupled with a thickness greater than can be produced by arresting the depositing process at the point at which the desired hole size has been attained. Broadly stated, the main object of the invention is to enlarge the holes of any screen without reducing the thickness, but more particularly it is to produce screen of larger hole size coupled with greater thickness than can be produced by simply depositing on a matrix of the character above described.

In the foregoing explanation of the nature of my process I have referred to "perforations" or "holes" that are to be enlarged. However, as will appear in the more detailed description of the process that is to follow, it is not necessary that there be initially actual holes or perforations extending from face to face of the sheet. On the contrary, favorable results may be obtained by starting the process with a sheet that is merely pitted—that is to say, e. g., a sheet produced by carrying the depositing process to the point at which the lands are contiguous or even merged together, provided pits are left. Such a

process is useful where an extraordinarily thick screen is desired, although ordinarily it is preferable that the deposit be not carried to the point at which the holes are entirely closed. I will use the term "recess" to describe both holes and pits.

Referring to the drawings,

Fig. 1 is a plan view of a metallic screen the holes of which are to be enlarged but the thickness of which is not to be reduced;

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

Figs. 3 and 4 illustrate intermediate steps in the process, Fig. 5 illustrating the final product; Figs. 6, 7, 8, and 9 illustrate the several steps in a modified form of the process;

Figs. 10, 11, 12, 13, 14, and 15 illustrate the several steps in another modified form of the process;

Fig. 16 illustrates an adaptation of the process to a screen the lands of which are contiguous and even merged together.

Describing more specifically the successive steps illustrated in Figs. 1-5, both inclusive, Fig. 1 shows a portion of screen produced by electrodeposition on a matrix of the character hereinabove-described, comprising the lands 10 running in one direction and the connecting lands 11 running in a direction at right angles thereto. For the purpose of describing this form of the invention, the material of this screen may be assumed to be electrolytically deposited copper, and it will be noticed that the perforations 12 are of relatively small diameter as compared with the width of the connecting lands 11. In other words, the dimension $a-b$ is small as compared with the dimension $b-c$. Likewise, the thickness $d-e$ is considerable in comparison with the dimension $a-b$. The dimension $a-b$ will at times be hereinafter referred to as the "hole size" and the dimension $b-c$ as the "land size."

The next step in the process now being described is to apply to both faces of the screen coatings 13 and 14 of some material that can be subjected to treatment that will selectively remove it without affecting the material of the screen itself and which is resistant to some material that selectively acts on the material of the screen without affecting the coating material. A suitable material for this purpose is a varnish ink preferably of a type that dries and hardens quickly and does not "run" excessively. The ink coatings may be applied by means of an inking roller, and as shown in Fig. 3 they cover only the faces of the screen, the walls of the holes or perforations remaining exposed.

The screen of Fig. 3 may now be subjected to the action of ferric chloride which acts destructively on the copper of the screen but does not affect the ink. As an alternative, it may be subjected anodically to electrolytic action. In either case the result is as illustrated in Fig. 4—viz., the walls of the holes have been eaten away as indicated by the numeral 15, leaving however the coatings 13 and 14 overhanging the enlarged holes 16. The final step consists in removing the ink coatings 13 and 14 which may be accomplished by applying a suitable solvent, such, for example, as acetone. The result is a screen as shown in Fig. 5.

While I have specified ink of the type above referred to as a suitable material for carrying out the form of the process now being described, it should be noted that ink is mentioned only as an example, other substances such as Bakelite varnish or tacky shellac being suitable.

In the modified process illustrated in Figs. 6 to 9, both inclusive, the entire surface of the screen, including not only the faces thereof but the walls of the holes as well, are first covered with a coating 20 of asphaltum. The asphaltum may even completely fill the holes as shown in Fig. 6, but this condition does not interfere with the process.

Next, the asphaltum is removed from the faces of the screen by any suitable method such as the abrasive action of sand paper, or a grinding wheel, or the cutting action of steel wool, or by rubbing, and thin layers 21 and 22 of nickel are then electrolytically deposited on the bare areas. Of course, the walls of the holes being still masked by the asphaltum receive no deposit.

The next step consists in removing the asphaltum that remains in the holes by dissolving in a suitable solvent, such as benzine or benzol. The screen of Fig. 7 (the asphaltum being assumed to have been removed as above stated) is then subjected to the action of a suitable agent that reacts destructively on the copper but does not affect the nickel deposit. An example of such an agent is a mixture of chromic and sulphuric acids in water, suitable proportions being about as follows:

Sulphuric acid	lbs..	2
Chromic acid	lb..	1
Water	gallons..	10

Another agent that may be used for the purpose is a solution of potassium cyanide. As an alternative, the screen may be subjected anodically to electrolytic action. The result of any one of these processes is the structure of Fig. 8. The nickel, in turn, may be removed by using it as an anode in a ten per cent. solution of hydrochloric acid.

A process somewhat akin to the process first described, but which is not illustrated, may comprise running the screen of Fig. 2 between two opposed gelatin or felt rollers impregnated with gold chloride. The result is a deposit of gold on the faces of the screen by the well-known phenomenon known as "replacement." The screen may be then etched with ferric chloride until the lands are reduced the desired amount, and any overhanging areas of the gold may be removed by abrasion or even left on.

The preferred process illustrated in Figs. 10 to 15 comprises first applying to the screen of Fig. 2 a coating 30 of some material that can be subjected to treatment that will selectively remove it without affecting the material of the screen

itself. A suitable material is chromium which may be applied simply by electrodeposition. Chromium is selected for the reason that it reacts to hydrochloric acid, while copper does not. On the other hand, copper reacts to ferric chloride, while chrome is passive to it.

In the next step illustrated in Fig. 11 the chrome covered faces of the sheet, as indicated at 31 and 32, have been activated—I. e., rendered capable of receiving a deposit of copper. In explanation, it should be stated that I have found that it is very difficult, if not impossible, to electrodeposit acid copper or nickel on the surface of an electrodeposit of chromium. To the extent that such a deposit takes place, it is spotty and the surface is far from completely covered; on the other hand, the surface of the chromium deposit may be activated so that it will readily take an electrodeposit of acid copper or nickel. The activation may be effected by rubbing, lightly grinding or abrading the chrome surface. Steel wool or pumice are suitable agents for the purpose. Activation of the faces only of the sheet is effected, the surfaces of the walls of the holes remaining passive. A chrome deposit of approximately .0002" thick lends itself to this step in the process very well.

In the next step, illustrated in Fig. 12, the screen of Fig. 11 is subjected as a cathode to an electrolytic copper bath, the result of which is to apply to the activated chrome areas coatings 33 and 34 of copper. These copper coatings, as stated above, cover only the activated chrome surfaces and in accordance with what has been said are capable of acting as a protective coating for the chrome, such that the chrome may be dissolved by the application of hydrochloric acid, while the copper remains intact.

In the next step illustrated in Fig. 13, the screen of Fig. 12 is subjected to the action of hydrochloric acid, the effect of which is to remove the chrome from the walls of the perforations leaving the copper exposed as shown at 35. As an alternative, the chrome may be de-plated by employing the screen as an anode in a caustic soda bath of a concentration of from 5 to 10%. But the copper deposit 33 and those portions of the chrome deposit 30 that are covered by the copper deposit 33 are not affected by the hydrochloric acid or by the deplating process, although, of course, both cut the chrome slightly under the copper as indicated at 36 and 37.

The screen of Fig. 13 is now ready for enlarging the perforations, and this is accomplished by subjecting it to the action of a suitable etching agent such as ferric-chloride, which not only acts destructively to remove material from the walls of the holes but also removes the protective coatings 33 and 34 of copper. The chrome, however, is not affected by the ferric-chloride, and the resulting product is shown in Fig. 14, the lands being indicated by the numeral 38 and the perforations by the numeral 39. Such of the original chrome deposit, however, as is shown in Fig. 13, still remains, and this may be easily removed by submitting the structure of Fig. 14 to the action of hydrochloric acid. An illustrative final product is shown in Fig. 15.

The foregoing process (of Figs. 10 to 15) may be carried out by using nickel in place of chrome. In the case of the nickel, however, it is necessary after the screen has been plated with the nickel, that the nickel surface be rendered passive to electrodeposition before the step illustrated in Fig. 11 is taken—I. e., before the faces of the

screen are activated. This may be done by immersing it in concentrated nitric acid. Thereupon, the nickel on both faces of the screen is activated as described with reference to Fig. 11 and in the same manner as in the case of chrome, and the copper deposit illustrated in Fig. 12 is then laid on. As an etching agent for removing the nickel from the walls of the holes, anodic treatment in 10% hydrochloric acid hereinbefore described would be used. The holes would then be enlarged by subjecting the screen to the action of a solution of chromic and sulphuric acids of about the proportion above given. It is not necessary in carrying out the process described with reference to Figs. 10 to 15 to start with a copper screen.

In describing the process of Figs. 10 to 15, I have not referred to a nickel screen as the basis of carrying it out. However, a nickel screen may be used in the same manner as a copper screen, with the additional feature that, for the purpose of enlarging the holes, dilute nitric acid could be used as an alternative for ferric-chloride. Another process of accomplishing the objects of the invention also involves the initial use of a nickel screen. The nickel is first rendered passive to electrodeposition by immersion in hot concentrated nitric acid. Preferably the concentration should be as high as possible and ought to be continued for a sufficient time for the nickel to acquire a degree of passivity at which it will not easily receive a deposit. Both surfaces of the screen are then activated by rubbing with pumice, steel wool or other abrasive or cutting agent. This leaves the walls of the holes resistant to a deposit while the surfaces of the screen are receptive to a deposit. It is then treated cathodically in an acid copper electrolytic bath and the abraded or rubbed surfaces receive a deposit, while the walls of the holes do not. The screen can then be subjected to electrolytic deplating in a 10% solution of hydrochloric acid which results in enlarging the holes without dissolving the copper. The copper may then, if desired, be removed by an application of chromic and sulphuric acid of about the proportions hereinabove mentioned.

Fig. 16 is a view similar to that of Fig. 2 except that in Fig. 16 the screen is shown with the lands run together as shown at 40, completely closing up the holes but leaving recesses 41. Each of the processes that has been described may be started with a screen of this type as well as with a screen in which the holes have been left open. However, the only advantage in so doing occurs when it is desired to make a screen the lands of which are extraordinarily thick as compared with the hole size.

I wish to make clear that in many, if not in most cases, the use of chemical reagents on the one hand, and electrolytic deplating on the other, are simply alternatives and that a person familiar with the art can readily substitute one for the other as occasion requires or permits.

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 illustrative and not limitative of my invention and that I reserve the right to make various changes in form, construction, and arrangement of parts and also to make various changes in process of manufacture falling within the spirit and scope of my invention, as set forth in the claims.

I claim:

1. The process of enlarging the perforations in foraminous sheet material, without substantially reducing the thickness of the sheet, which comprises the steps of covering the surfaces of the sheet including the walls of the perforations with a coating of material resistant to an etching agent which is destructively reactive on the material of the sheet, then rendering the areas of coating that do not cover the walls of the perforations resistant to a second etching agent that acts to remove the remaining material of the coating but which does not react on the material of the sheet, removing the said coating from the walls of the perforations by the action of said second agent, and removing the material of the walls of the perforations to an extent sufficient to reduce the width of the lands to a desired extent, by means of the first mentioned agent.

2. The process of enlarging the holes of foraminous sheet without substantially reducing the thickness of the sheet, which comprises the steps of covering the surface of the sheet including the walls of the holes with a coating of material resistant to a dissolving agent that destructively reacts on the material of the sheet, rendering the areas of coating that do not cover the walls of the holes resistant to a second dissolving agent that acts to remove the remaining material of the coating and which does not react on the material of the sheet, removing the said coating from the walls of the holes by subjecting the sheet to the action of said second agent, removing the material of the walls of the holes to an extent sufficient to reduce the width of the lands to a desired extent by means of the first mentioned agent, and removing the resistant portion of said coating by a dissolving agent that does not affect the material of the sheet.

3. The process of enlarging the holes of foraminous copper sheet without substantially reducing the thickness thereof, which comprises the steps of electroplating the surface of the copper sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not constitute the walls of the holes, electroplating the said areas with a coating of copper, removing the chromium from the walls of the holes by subjecting the sheet to the action of hydrochloric acid, subjecting the sheet to the action of ferric-chloride until the land width is reduced to a desired extent and the copper coating is removed, and removing the remaining chromium by subjecting the sheet to the action of hydrochloric acid.

4. The process of enlarging the holes of foraminous copper sheet without substantially reducing the thickness thereof, which comprises the steps of electroplating the surface of the sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not cover the walls of the holes, electroplating the said areas with copper, removing the chromium from the walls of the holes by subjecting the sheet to the action of hydrochloric acid, and subjecting the sheet to the action of a copper etching agent until the land width is reduced to a desired extent and the copper coating is removed.

5. The process of enlarging the holes of foraminous copper sheet without substantially reducing the thickness thereof, which comprises the steps of electroplating the surface of the

sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not cover the walls of the holes, electroplating the said areas with copper, removing the chromium from the walls of the holes by an etching agent that is passive with respect to the copper, and subjecting the sheet to the action of a second etching agent that reacts destructively on the copper but does not affect the chromium until the land width is reduced to a desired extent and the copper coating is removed.

6. The process of enlarging the holes of foraminous copper sheet without substantially reducing the thickness thereof, which comprises the steps of electroplating the surface of the sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not cover the walls of the holes, electroplating the said areas with copper, removing the chromium from the walls of the holes by the action of an etching reagent which acts destructively on the chromium but does not affect the copper, and subjecting the sheet to the action of a second etching reagent that acts destructively on the copper but does not affect the chromium until the land width is reduced to a desired extent and the copper coating is removed.

7. The process of enlarging the holes in foraminous metal sheet without substantially reducing the thickness of said sheet, which comprises the steps of rendering the walls of the holes inactive to electrolytic deposition and the faces of the sheet active to electrolytic deposition of an adherent metal coat, electroplating the activated areas with a metal resistant to an etching agent which is capable of dissolving the metal of the body of the screen, and subjecting the sheet to the action of such agent for a period of time sufficient to reduce the width of the lands to a desired extent.

8. The process of enlarging the holes in foraminous metal sheet with substantially reducing the thickness of said sheet, which comprises the steps of covering by electroplating the surface of the sheet including the walls of the holes with a coating of a metal passive to electrolytic deposition but capable of being rendered active to the same, rendering active to electrolytic deposition of an adherent metal coating those areas of the coating that do not cover the walls of the holes, electroplating the activated areas with a metal that is resistant to a given etching agent that destructively reacts on the coating, removing the uncovered areas of said coating by the application of said agent, and subjecting the sheet to the action of a second etching agent for a period of time sufficient to enlarge the diameters of the holes to a desired extent.

9. The process of enlarging the holes in foraminous metal sheet without substantially reducing the thickness of said sheet, which comprises the steps of electroplating the surface of the sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not constitute the walls of the holes, electroplating the said areas with a coating of copper, removing the chromium from the walls of the holes by subjecting the sheet to the action of an etching agent that etches chromium but does not affect copper, then subjecting the sheet to the action of an etching agent that etches copper but does not affect chromium until the land width is reduced to a desired extent and the copper coating is removed, and then removing the remaining chromium by subjecting the sheet to the action of an etching agent that etches chromium but does not affect copper.

prises the steps of electroplating the surface of the sheet including the walls of the holes with a second metal capable of becoming inactive to electrolytic deposition but capable of being activated to receive such deposition, rendering active to electrolytic deposition those areas of the second metal that do not cover the walls of the holes, electroplating the said activated areas with a metallic coating, selectively removing the unplated areas of the said second metal by means of an etching agent that does not affect the metal of the sheet or the metallic coating, and then subjecting the sheet to the action of a second etching agent which destructively reacts on the exposed metal of the sheet and/or the metallic coating for a period of time sufficient to reduce the land width to a desired extent and to remove the said metallic coating.

10. A process of enlarging the holes in foraminous metal sheet without substantially reducing the thickness of the sheet, which comprises the steps of electroplating the surface of the sheet including the walls of the holes with a coating of a second metal, the surface of which is passive to electrolytic deposition, which said metal is resistant to the action of an etching agent that destructively reacts on the metal of the sheet, then rendering the faces of the sheet except the walls of the holes active to electrolytic deposition of an adherent coating of metal, then electroplating the active areas with a third metal on which the first-mentioned agent destructively reacts, removing the second metal from the walls of the holes by means of a second etching agent that does not affect the first or the third metals, thus leaving the metal of the sheet constituting the walls of the holes exposed, and then subjecting the sheet to the action of the first-mentioned agent for a period of time sufficient to reduce the land width to a desired extent and to remove the said third metal.

11. The process of enlarging the holes of foraminous copper sheet without substantially reducing the thickness thereof, which comprises the steps of electroplating the surface of the copper sheet including the walls of the holes with chromium, rendering the chromium active to electrodeposition of an adherent coating of copper over those areas that do not constitute the walls of the holes, electroplating the said areas with a coating of copper, removing the chromium from the walls of the holes by subjecting the sheet to the action of an etching agent that etches chromium but does not affect copper, then subjecting the sheet to the action of an etching agent that etches copper but does not affect chromium until the land width is reduced to a desired extent and the copper coating is removed, and then removing the remaining chromium by subjecting the sheet to the action of an etching agent that etches chromium but does not affect copper.

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