United States Patent [19]

Greenwood et al.

[11] **3,783,779**

[45] **Jan. 8, 1974**

[54] **ROTARY SCREEN PRINTING CYLINDER**

[75] Inventors: **Aaron O. Greenwood,** Greenwood; **Ramon J. Magee,** Independence; **Stanley W. Otto,** Platto City, all of Mo.

[73] Assignee: **Hallmark Cards, Incorporated,** Kansas City, Mo.

[22] Filed: **May 20, 1971**

[21] Appl. No.: **145,516**

Related U.S. Application Data

[62] Division of Ser. No. 844,777, July 25, 1969, Pat. No. 3,610,143.

[52] **U.S. Cl.** **101/127,** 101/128.2

[51] **Int. Cl.** **B44a 3/06**

[58] **Field of Search** 101/127, 125, 126, 101/128.2, 128.4, 426, 401.1; 161/129, 109; 96/36.4

[56] **References Cited**

UNITED STATES PATENTS

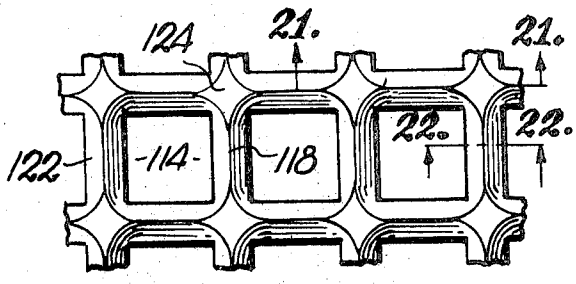
2,419,028	4/1947	Norris	101/128.2 X
2,543,046	2/1951	Murray	101/128.4 X
3,302,561	2/1967	Edwards	101/127 X
2,829,460	4/1958	Golay	101/127 X
2,241,380	5/1941	Gfeller	101/127 X
2,622,516	12/1952	Heath	101/128.4
2,115,855	5/1938	Holman	101/128.4 X
2,543,045	2/1951	Murray	101/426 X
1,954,672	4/1934	Kavanaugh	101/128.2

Primary Examiner—Robert E. Pulfrey
Assistant Examiner—E. M. Coven
Attorney—Schmidt, Johnson, Honey & Williams

[57] **ABSTRACT**

A rotary screen printing stencil is produced by etching techniques. A cylindrical base member is first provided with a layer of etchable material on the outer surface thereof. An etch-resistant coating is provided over selected portions of the etchable material corresponding to the area surrounding the design to be printed and the grid pattern of the printing stencil. The etchable material is then removed in those areas thereof not protected by the etch-resistant coating. The resulting stencil having a foraminous design area with a grid pattern therein and an imperforate section surrounding the design area is then separated from the base member.

4 Claims, 22 Drawing Figures



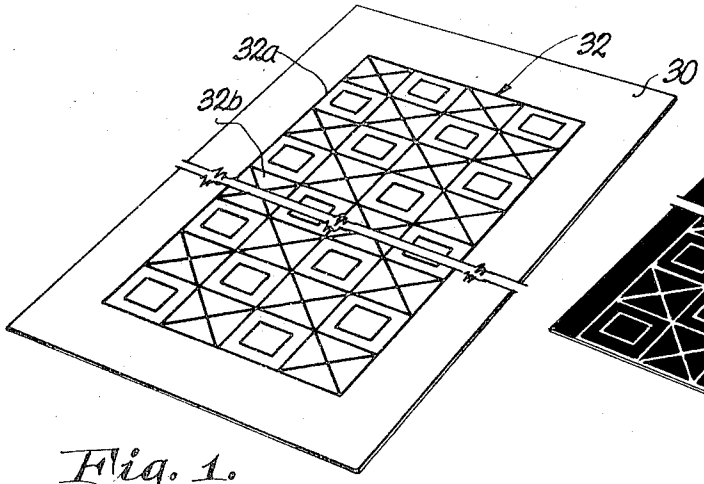


Fig. 1.

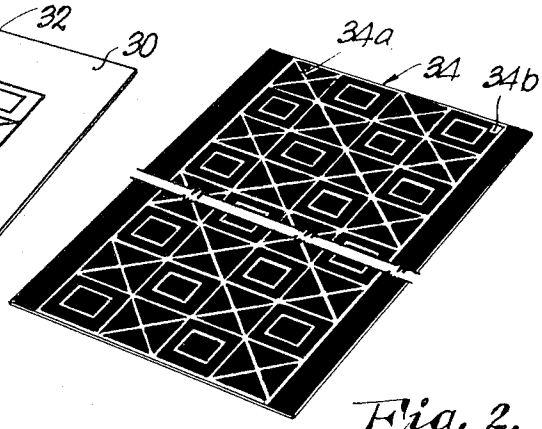


Fig. 2.

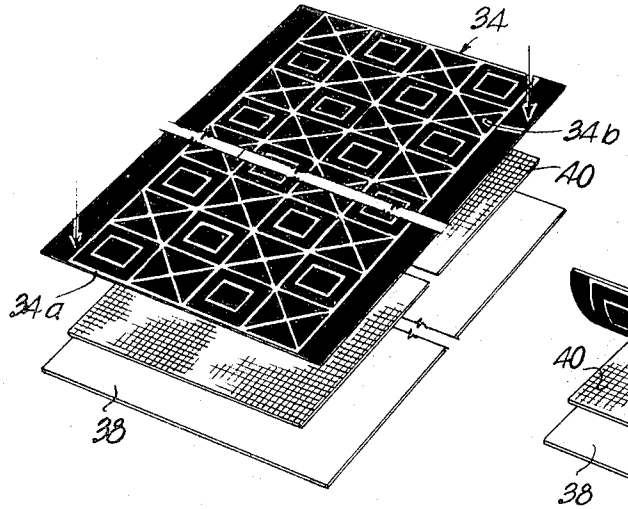


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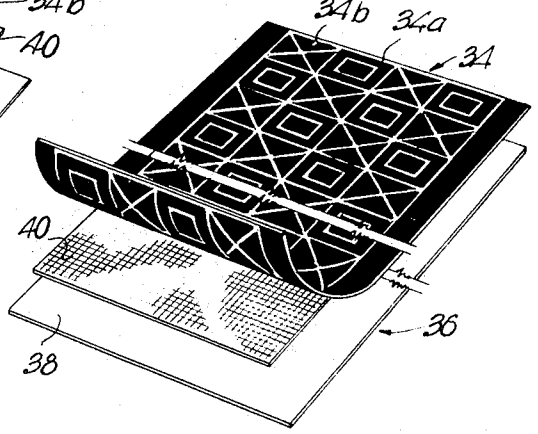


Fig. 4.

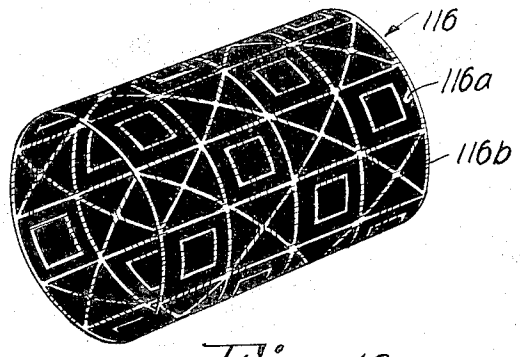


Fig. 18.

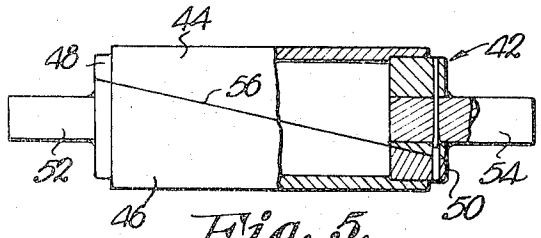


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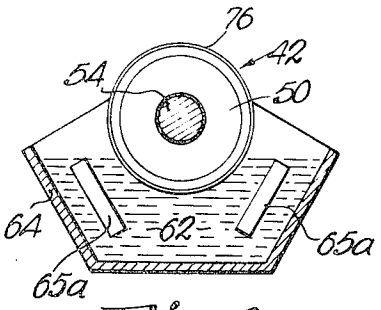


Fig. 8.

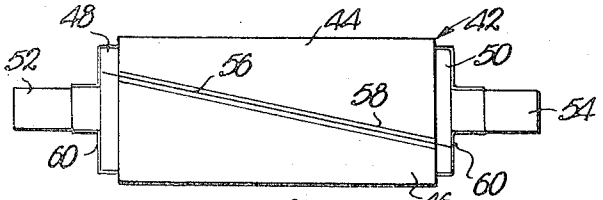


Fig. 6.

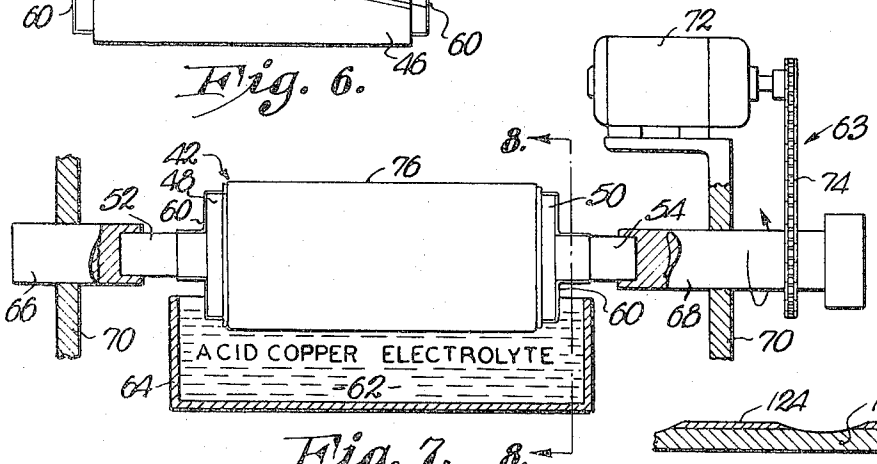


Fig. 7.

Fig. 21.



Fig. 22.

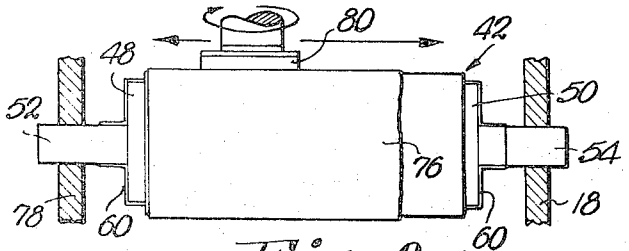


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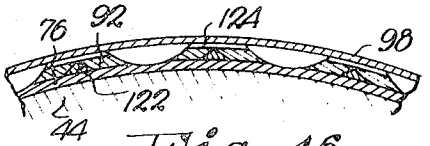


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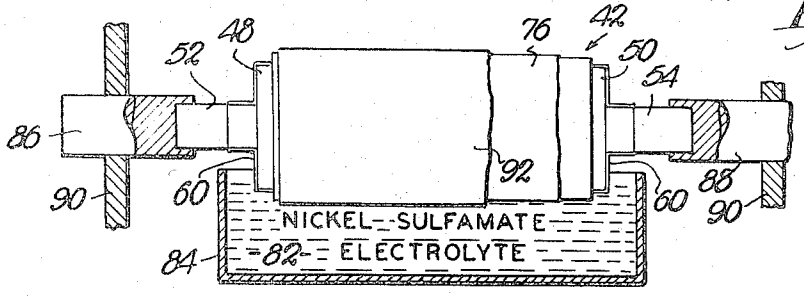


Fig. 10.

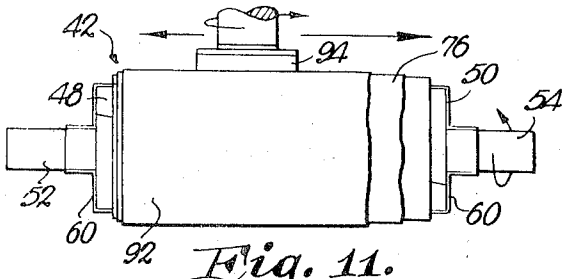


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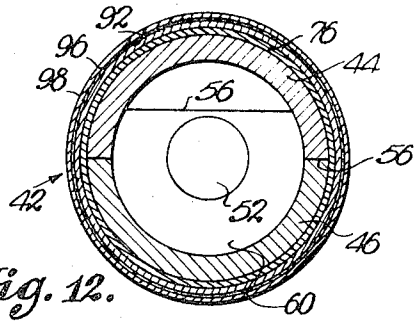


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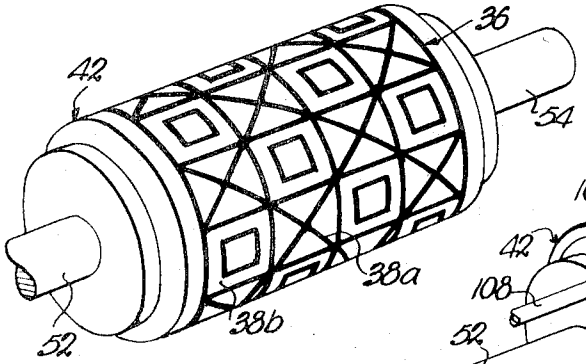


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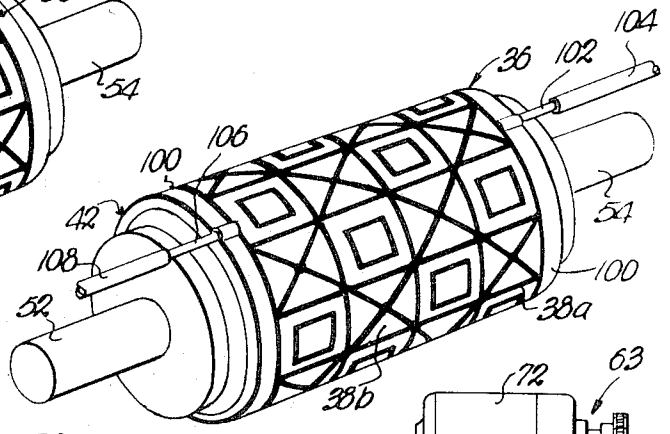


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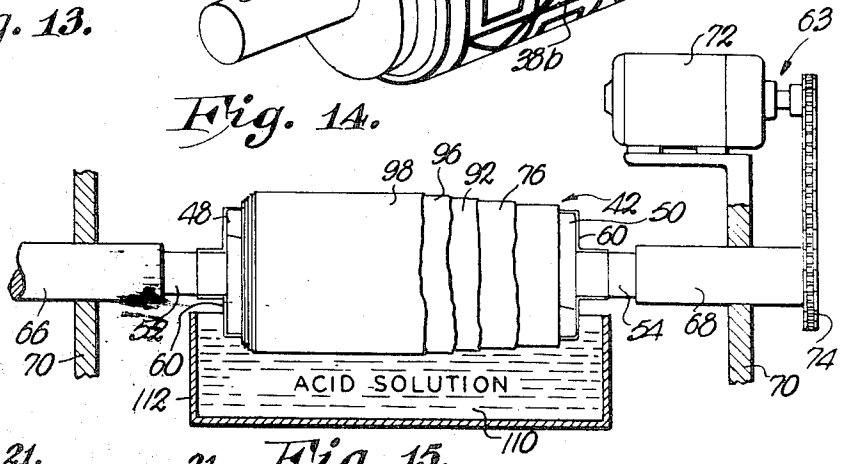


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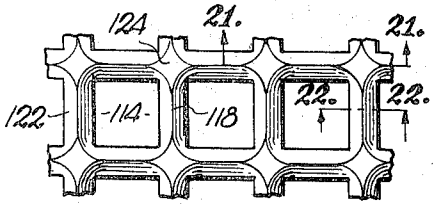


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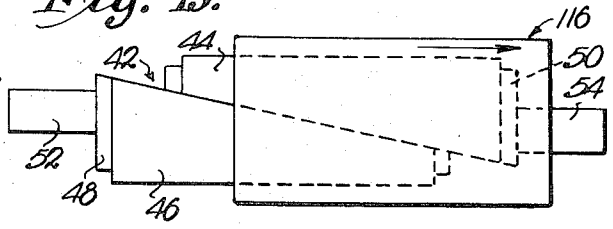


Fig. 17.

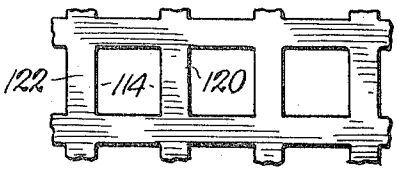


Fig. 20.

ROTARY SCREEN PRINTING CYLINDER

This is a division of my copending application Ser. No. 844,777, filed Jul. 25, 1969 now U.S. Pat. No. 3,610,143..

This invention relates to screen printing apparatus and, more particularly, to rotary screen printing stencils of the type having a foraminous design area with a grid pattern therein and an imperforate section surrounding the design area, as well as to a unique method of producing such stencils.

Rotary screen stencils have long been proposed for use in mass production printing operations, but the value of such stencils has been questionable where accuracy is important, as in the printing of paper as opposed to textiles, and particularly in multicolor operations where printing steps are sequentially conducted on a web of paper being fed through the printing apparatus. For example, if it is desired to print a four color design, using rotary stencils where each prints a respective color, four rotary stencils must be disposed in precise relative relationship to effect proper sequential printing of the design on the web of paper with all colors in required register. If one of the rotary stencils has a circumference which is as much as 0.01 inch different from that of another stencil, the two corresponding colors of these stencils, after 100 revolutions of the latter, would be offset one inch relative to each other with respect to the original spacing on the paper. This inaccuracy is multiplied when a plurality of stencils are employed and thus the successful use of mass production operations utilizing rotary stencils is limited due to the inherent characteristics of the process. Although electronic registry apparatus can be provided, it is expensive and still fails to produce exact registry of images at all times. Although this disadvantage may be somewhat obviated by manual control and adjustments, a high degree of accuracy is not obtainable.

Another disadvantage of rotary screen stencils has been the problem of seams inherently being present on the rotary printing surface which interrupt the continuity of the design during printing operations. This problem arises from the need to prepare the artwork representing the design to be printed on an initially flat surface. It has been the practice to prepare the stencil design on an initially flat piece of flexible paper or the like which is then looped or wrapped around a support cylinder so that the opposed ends thereof will abut each other when the sheet is glued, taped or otherwise secured to the supporting cylinder therefor. The support cylinder is treated so that only certain areas are susceptible to plating and the desired rotary stencil is then plated onto the support cylinder.

While prior methods of this type are often referred to as capable of producing "seamless" stencils, the lines of juncture between the various abutting sections cause depressions to be formed in the outer surface of the plated metallic layer. The resulting seam in the stencil printing surface prevents the formation of an uninterrupted design on a continuously fed web of paper. Thus, the printing surfaces produced by prior methods are more accurately referred to as "continuous" in the sense that a cylinder or rotary member presents a continuous printing surface, but not one which is free of design interrupting seams.

Another major disadvantage of prior plating methods for producing rotary screen stencils has been the fact that the ink passages presented by the grid pattern of the foraminous design area are closed off one from the other in the sense that each opening in the screen is separated from an adjacent opening by a thin metallic wall which corresponds to the grid pattern of the stencil. This construction tends to block the flow of ink between adjacent passages with the result that the physical properties of the ink must be carefully controlled. However, even when such control is exercised, extremely fine designs are not possible because of the relatively large quantity of ink required to obtain the necessary flow.

Still another major disadvantage of prior methods utilizing plating techniques is the inherent characteristic of the plating process which limits production to stencil screens wherein the openings are of necessity no smaller than each individual area which can be effectively masked from the plating operation. Thus, the minimum size of the openings in the stencil screen will be limited by the preciseness of the masking technique employed.

The present method provides a screen printing stencil without the numerous deficiencies present in stencils produced according to prior methods. The circumference of the printing stencil may be controlled to an extent not previously achievable by virtue of the provision of a base member for the stencil which has a supporting surface that is capable of being ground and lapped to an extremely precise preselected dimension. A layer of etchable material is formed on the supporting surface and an etch-resistant coating is applied to selected portions of the material. Those portions of the material not protected by the etch-resistant coating correspond to the ink passages in the finished printing stencil. These areas of the material are etched away to present the ink passages and the resulting screen is removed from the base member to provide the printing stencil. Chemical etching is employed which results in adjacent passages which are in intercommunication to facilitate the flow of ink onto the paper rather than blocking the flow thereof as was characteristic of prior screens and methods of preparing the same. It is also characteristic of the etching process that the passages formed in the etchable material are not perpendicular to the plane of the material but are formed with slanted sidewalls which result in the openings on one side of the stencil being significantly smaller than the openings on the other side thereof. This permits the formation of passages in the stencil that are of a smaller area than is possible with prior methods. The smaller ink passages permit finer detail in the stencil design.

It is, therefore, a very important object of this invention to provide a method for producing rotary screen stencils wherein the stencil is formed on a base support that is capable of being machined to a precise degree, thereby resulting in a printing stencil that is dimensionally accurate to thereby allow continuous mass production printing to be achieved without the need for complex registry equipment and frequent adjustments of the printing apparatus.

Another important object of the invention is to provide a method for producing a rotary screen stencil wherein a truly seamless printing surface is formed, although the design serving as a pattern for the stencil is formed on an initially flat sheet of material.

Another extremely important object of the invention is to provide a printing stencil wherein the ink passages are interconnected on the side of the stencil that

contacts the printing surface, thereby facilitating the ink flow and permitting the use of a relatively small quantity of ink as required in printing of very fine details.

Still another important object of the invention is to provide a printing stencil wherein the ink passages on the side of the stencil that contacts the printing surface are interconnected to facilitate the flow of ink and yet wherein the stencil surface that receives the inking solution is perfectly smooth to permit movement of the ink squeegee thereover without causing excessive wear of the squeegee and in such a manner as to insure an accurate flow of ink onto the printing surface.

A still further object of the instant invention is to provide a method of producing a screen printing stencil wherein etching techniques are utilized to achieve funnel-shaped ink passages of extremely small size thereby resulting in a printing screen capable of very fine printing detail.

Other objects of the invention will be made clear or become apparent from the following specification and accompanying drawings, wherein:

FIG. 1 is a perspective view of an original positive line drawing of the design for the rotary printing screen;

FIG. 2 is a perspective view of a photographic negative prepared from the original positive line drawing of FIG. 1;

FIG. 3 is a perspective view showing the exposure operation employed in preparation of an emulsion positive from the photographic negative and a gravure line screen;

FIG. 4 is a perspective view showing the way in which the photographic negative and the line screen are removed from the emulsion film;

FIG. 5 is a schematic, side elevational view, partially in cross section of a split mandrel that serves as a base member for a rotary screen printing stencil;

FIG. 6 is a side elevational view of the split mandrel with the hairline seam between the two mandrel halves covered with a conductive material, and the ends of the mandrel taped to prevent electrodeposition thereon;

FIG. 7 is a schematic, side elevational view of the split mandrel being rotated in a solution of copper electrolyte, with the electrolyte bath and portions of the mandrel supporting structure being shown in cross section;

FIG. 8 is a cross-sectional view taken along line 9—9 of FIG. 7;

FIG. 9 is a schematic, side elevational view of the way in which the electroformed copper layer on the split mandrel is precisely dimensioned by use of a grinding head, with a portion of the copper layer being broken away for purposes of illustration;

FIG. 10 is a schematic, side elevational view of the split mandrel with the electroformed copper layer thereon disposed in a nickel sulfonate electrolyte bath for deposition of a nickel layer on the copper layer, and wherein the nickel electrolyte bath and portions of the mandrel supporting structure are shown in cross section and the electroformed nickel and copper layers are partially broken away for purposes of illustration;

FIG. 11 is a schematic, side elevational view of the split mandrel illustrating the preferred process for milling the outer surface of the nickel layer to reduce the diameter thereof to a preselected value, and with the respective nickel and copper layers being partially broken away;

FIG. 12 is an enlarged, end elevational view of the split mandrel after layers of copper, nickel, and copper have been successively formed on the mandrel and a layer of photoresist applied over the outermost copper layer, with the supporting surface of the mandrel and the layers formed thereon shown in cross section;

FIG. 13 is a perspective view of the split mandrel with the emulsion positive placed thereon;

FIG. 14 is a schematic, perspective view similar to FIG. 14, but illustrating a vacuum operation for pulling the emulsion positive down onto the photoresist that forms the outermost layer on the split mandrel;

FIG. 15 is a schematic, side elevational view of the mandrel placed in an acid solution to etch away those portions of the metal layers not protected by the photoresist and wherein the various layers of the metal and photoresist on the mandrel are partially broken away for purposes of illustration, and with the bath of acid solution and portions of the mandrel supporting structure being shown in cross section;

FIG. 16 is an enlarged, fragmentary, cross-sectional view of the printing stencil on the split mandrel after the mandrel has been subjected to the acid bath to cause portions of the etchable material to be removed but before the protective layer of photoresist has been washed away;

FIG. 17 is a schematic, side elevational view of the way in which the parts of the split mandrel are separated to facilitate removal of the stencil screen therefrom;

FIG. 18 is a perspective view of a completed seamless rotary printing stencil;

FIG. 19 is an enlarged, fragmentary, top plan view of a part of the printing stencil;

FIG. 20 is an enlarged, fragmentary, partial bottom plan view of that part of the printing stencil shown in FIG. 18;

FIG. 21 is an enlarged, cross-sectional view of a portion of a printing stencil taken along line 21-21 of FIG. 19; and

FIG. 22 is an enlarged, cross-sectional view of a portion of a printing stencil taken along line 22—22 of FIG. 19.

FIG. 1 illustrates a piece of paper or relatively stiff cardboard 30 on which a positive line drawing in the nature of a design 32 has been drawn by hand or reproduced thereon in any desired manner as by photographic techniques in such a manner that the black lines 32*a* correspond to the final design desired to be imprinted on a continuous web of paper or the like. The lines 32*a* are thus separated by non-image bearing areas 32*b*. A photographic negative 34 of the original artwork 32 is then prepared using conventional photographic processes. The negative 34 has clear lines 34*a* corresponding to lines 32*a* of the original artwork and darkened areas 34*b* corresponding to the areas 32*b* of the original artwork.

An emulsion film 36 which is preferably constructed of a dimensionally stable synthetic resin material such as "Mylar" or "Cronar" proprietary products of E. I. du Pont de Nemours and Co., Wilmington, Delaware, is placed on a suitable support with its emulsion side 38 facing upward. A conventional gravure line screen 40 and the negative 34 are then placed over the emulsion film 36 as represented schematically in FIG. 3, and the

film 36 subjected to a suitable source of radiation such as light. This results in the formation of a positive of the original artwork on the film 36 with a negative image of the line screen 40 superimposed within the lines 32*a* representing the design to be printed.

Once the exposure step is completed, the screen 40 and the negative 34 are removed from the film 36 as illustrated in FIG. 4, and after development the film 36 has lines 38*a* corresponding to the lines 32*a* of the design to be printed and areas 38*b* corresponding to the non-image bearing areas 32*b* of the original artwork. Although the lines 38*a* are illustrated as darkened lines in FIG. 13 and are generally light-impenetrable, it is to be understood that a light-penetrable grid pattern is present within these lines. The areas 38*b* are light-penetrable for purposes to be made clear hereinafter.

A cylindrical split mandrel designated generally by the numeral 42 serves as the base member upon which the rotary screen stencil is formed. The mandrel 42 is made up of two tapered sections 44 and 46 illustrated in their assembled positions in FIG. 5. Sections 44 and 46 have a pair of end plugs 48 and 50 provided with respective shaft sections 52 and 54 extending outwardly therefrom. Thin, inclined, opposed seams or lines of juncture 56 are present where the sections 44 and 46 abut when in their assembled positions.

The lines of juncture 56 are covered with a brushed-on deposit of silver-laden lacquer 58 as illustrated in FIG. 6 to make the two sections 44 and 46 one electrically conductive body. It is also desirable to mask the ends 48 and 50 of the mandrel 42 with a layer of tape 60 to prevent the deposition of metal thereon in subsequent steps of the process.

The assembled mandrel is next coated with an electrically conductive release coating. An effective solution which is conveniently applied by simply wiping it on the surface of the mandrel consists of 8 ounces of nickel sulfate salts, 8 ounces of nickel ammonium salts, and 8 ounces of hyposulfite, dissolved in one gallon of water. Alternatively, precipitated silver may be sprayed over the entire mandrel surface. This renders the mandrel electrically conductive and it is now ready for subjection to a plating bath.

The mandrel 42 is partially submerged in a copper electrolyte solution 62 that is confined in a tank 64 having a pair of electrodes 65*a* therein. Apparatus generally designated 63 for turning the mandrel 42 while the latter is submerged in the solution 62 includes sleeves 66 and 68. The shafts 52 and 54 of the mandrel 42 are keyed to the sleeves 66 and 68 respectively, the sleeves in turn, being rotatably received by appropriate supporting structure 70 which is partially visible in FIG. 7. Sleeve 68 is operably connected to a driving mechanism that includes a motor 72 and a drive chain 74 for rotating the mandrel 42 as it is submerged in the electrolyte solution 62. The plating apparatus which includes electrodes 65*a* is energized under operating conditions to cause a layer of copper to be formed on the conductive surface of the mandrel 42 at a controlled rate. It is preferred that the copper plating step be continued until a smooth, continuous layer of approximately 0.004 inches of copper is deposited on the mandrel surface.

The mandrel 42 having the electroformed copper layer 76 thereon is then positioned in appropriate supporting structure 78 and rotated by conventional driving mechanism while the copper layer 76 is ground and lapped by a rotating grinder head 80 which is reciprocated as the grinding wheel is rotated. Machining of the copper layer 76 is continued until the outside dimension thereof is equal to the desired inside dimension of the stencil screen yet to be formed. It is preferred that at least 0.001 inch of the copper layer 76 be removed to insure the formation of a perfectly cylindrical supporting surface for the stencil. In addition to presenting a firm surface which is capable of being machined to present a perfect cylinder, the copper layer 76 veils any imperfections in the split mandrel that would otherwise effect the quality of the stencil. In addition, the copper layer 76 serves as a disposable backup member that protects the mandrel during the subsequent etching step of the process. It is to be understood however, that the copper layer 76 is not essential in practicing the instant invention and, if desired, the stencil may be formed directly on the split mandrel 42 providing the latter has been properly prepared in a manner similar to that discussed for the copper layer 76 and lacquer 58 is used to fill joints 56.

After the copper layer 76 is ground and lapped to present a truly cylindrical surface, the precisely ground mandrel is coated with an electrically conductive release coating of the same composition as previously discussed for coating the mandrel 42, or in the alternative, a coating of precipitated silver sprayed onto the layer 76. After the mandrel 42 has been rendered electrically conductive it is partially submerged in a solution of nickel sulfamate electrolyte 82 that is confined in an appropriate tank 84 having an electrode arrangement therein similar to that described in connection with the copper electrolyte solution 62 shown in FIG. 8. The shafts 52 and 54 of the mandrel 42 are keyed to sleeves 86 and 88, the latter being rotatably received by a supporting structure 90 similar to the structure 70 shown in FIG. 7. It is also to be understood that the sleeve 88 is connected to appropriate driving mechanism similar to the manner in which the sleeve 68 is driven by the apparatus 63 in FIG. 7. As the mandrel 42 is rotated and the plating apparatus energized, a layer of nickel 92 is plated onto the copper layer 76 from the nickel sulfamate bath. It is preferred that the nickel-plating step be continued until a smooth, continuous layer of approximately 0.0035 inches of nickel is deposited on the copper layer 76.

After the nickel plating step is completed, the nickel surface 92 is ground and lapped by a rotating and reciprocating grinder head 94 while the mandrel 42 is rotated as illustrated schematically in FIG. 11. It is preferred that the machining of the nickel surface 92 be continued until the nickel layer has a uniform thickness of approximately 0.003 inches.

Next, the nickel layer 92 is coated with an electrically conductive coating such as the composition previously described for use in rendering the split mandrel and the copper layer 76 electrically conductive or, as discussed previously, by spraying the nickel layer 92 with precipitated silver.

The copper plating step is then repeated to deposit a layer of copper 96 approximately 0.005 inches thick on the nickel layer 92. The copper layer 96 is ground and lapped in the manner described above in connection with the copper layer 76 and as illustrated in FIG. 9. The plated and finished mandrel 42 is then rotated while a thin coating of photoengravers'enamel 98, preferably Eastman KPR, a product of Eastman Kodak CO.,

Rochester, New York, is sprayed or otherwise applied to the outermost copper layer **96.** The layer of enamel **98,** which serves as a "photoresist" for the subsequent etching step, should be of a thickness to uniformly coat the entire plated surface of the mandrel **42.** KPR photosensitive enamel is preferably employed because it is ultraviolet sensitive and can be handled more easily than emulsions which are sensitive to normal daylight.

FIG. **12** illustrates the various layers that have been formed on the mandrel **42** during the preceding steps. Next, the emulsion positive **36** is wrapped around the mandrel **42** so that opposed ends of the film sheet **36** are in exact abutting relationship. In this respect, the design **32** is preferably laid out so that when the emulsion positive **36** is wrapped around a mandrel **42** of predetermined diameter, the opposed margins of the design **32** are in correctly aligned relationship. The abutting ends of the emulsion film **36** are then secured tightly together by a piece of conventional pressure-sensitive cellophane tape placed over adjacent sections of the abutting ends. Cellophane tape **100** is also wrapped around opposed sides of the sheet of emulsion film **36** in circumscribing relationship to the mandrel **42.**

When the emulsion positive **36** has been tightly secured to the surface of the mandrel **42,** a needle **102** connected to a vacuum line **104** is inserted beneath the layer of cellophane tape **100** at one end of the mandrel **42,** and another needle **106** connected to a vacuum line **108** inserted beneath the cellophane tape **100** at the opposite end of the mandrel. A vacuum is then applied to the lines to cause all air to be drawn from beneath the film **36** and to cause the latter to very closely adhere to the layer of enamel **98** that forms the outer surface of the mandrel **42.** A vacuum of approxkmately 10 to 15 inches of mercury negative pressure in lines **104** and **108** is sufficient for the desired purpose.

The entire mandrel **42** with the emulsion positive **36** secured thereto is then exposed to a source of ultraviolet light. The darkened lines **38***a* corresponding to the lines **32***a* of the design to be printed are generally impenetrable by the ultraviolet light except for the grid lines that have been superimposed thereon. Thus, those portions of the enamel **98** directly beneath the lines **38***a* are not hardened except for the grid pattern. On the other hand, the areas **38***b* of the film **36** are light-penetrable and those portions of the enamel **98** beneath the areas **38***b* are hardened by the irradiation step.

After the irradiation step has been completed, the emulsion positive **36** is removed from the mandrel **42** and the enamel layer **98** developed with conventional Eastman Kodak KPR developer, preferably while the mandrel **30** is spun in a developer tank. During developing, those portions of the enamel **98** which were exposed to the ultraviolet radiation are not affected by the solution but those portions of the enamel **98** that were not subject to the UV radiations are washed away to expose the bare metal therebelow. This results in the enamel **98** covering only those areas of the copper layer **96** which, in the completed stencil, will correspond to the non-image bearing areas **32***b* of the design to be printed plus the screen grid pattern within the design areas. Those areas of the copper layer **96** which are to be removed to form ink passages in the completed stencil are no longer covered by the enamel layer **98.**

The next step of the process is illustrated in FIG. **15** wherein the mandrel **42** having layers of copper **76,** nickel **92,** copper **96,** and photoresist **98** is partially immersed in an acid etching solution **110,** which is preferably ferric chloride having a strength of 48° Baume, confined in an appropriate container **112.** Apparatus **63,** previously described in conjunction with the copper plating step, is provided for turning the mandrel **42** while the latter is submerged in the etching solution **110.** The layers of material on the mandrel **42** are maintained in contact with solution **10** until the copper layer **96** and the nickel layer **92** are dissolved to an extent to cause passages **114** to be formed therethrough. Etching should be continued until holes of proper size are formed in layers **92** and **96** while small dimples are formed in layer **76** underneath the individual passageways. When the etching step is completed, the mandrel **42** is removed from the etching solution **110** and placed in a rinsing bath (not shown) capable of dissolving the photoresist wherein the layer of enamel **98** is removed from the mandrel **42.**

As illustrated in FIG. **17,** the two sections **44** and **46** of the mandrel **42** are then pulled apart to release a completed cylindrical stencil **116** therefrom. The inner copper layer **76,** which is partially consumed by the etching solution, is discarded and the completed stencil **116** has a foraminous design area **116***a* corresponding to the lines **32***a* of the original artwork **32,** and an imperforate section **116**b surrounding the design area **116***a* and corresponding to the non-image bearing areas **32***b* of the original artwork.

The action of the etching solution **110** is best illustrated in FIG. **16.** The bimetal construction of the stencil **116,** together with the fact that the etching solution **110** is being consumed during the etching step, results in an etching action which is more degradative to the copper layer **96** than to the nickel layer **92.** The action of the etching solution **110** thus does not proceed downwardly in a straight line but in opposed slanted lines. It is also to be noted that the etching solution **110** "undercuts" the layer of resist enamel **98** in all areas except where two lines of the grid pattern intersect. This produces a grid pattern wherein the passages **114** in the copper layer **96** and the nickel layer **92** present openings **118** at one end of the passages **114** that are interconnected and generally hemispherically shaped, and openings **120** at the opposite ends of the passages **114** that are disconnected and generally planar. The openings **120** are separated by linear sections **122** of generally triangular cross section, the sections **122** being formed only in the nickel layer **92** as a result of the etching solution **110** having removed the copper layer **96** above the sections **122.** As the effective area of the resist enamel **98** is larger where the grid lines intersect, the etching solution **110** does not entirely remove the copper layer **96** beneath these points of intersection. This results in the formation of a copper post **124** at each point of intersection of the linear sections **122.**

As clearly illustrated in FIG. **18,** the openings **118** are interconnected and generally hemispherically-shaped to facilitate the flow of ink across a surface receiving the printing ink. The posts **124** are the only portions of the stencil **116** on the side of the openings **118** that contact the printing surface. On the other hand, as clear in FIG. **19,** the side of stencil **116** in which the openings **120** appear is flat to present an effective sur-

face for receiving the inking solution and over which the ink squeegee will easily move.

While in the preferred embodiment of the invention a bimetal construction of nickel and copper has been described which permits the use of one single strength etching solution to achieve the desired "undercutting action" and produce passages 114 of the desired size and configuration, it will be appreciated that the novel method herein described can be practiced using a single metal layer. For example, a single layer of either copper or nickel could be electroformed over an appropriately prepared base member and then etched. In either such case, however, it has been found desirable to flash the outer surface of the electroformed metal with chromium to increase the abrasion resistance of the metal and, in the case of copper, to prevent oxidation of the copper metal.

It is also clear that while the invention has been described as having particular application to the production of seamless stencils for rotary screen printing apparatus, the advantages achieved with the novel process find application in all areas of screen printing.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A screen printing stencil for a rotary screen printing press and of the type having a foraminous design area presented by a grid pattern and an imperforate section surrounding the design area, said stencil comprising:

a sheet of chemically etchable metal having a first metallic layer presenting an outwardly facing first surface,

a discontinuous second metallic layer integral with said first layer and presenting an outwardly facing opposed second surface, and

a plurality of ink passages connecting said first and second outwardly facing surfaces, said passages being characterized by outwardly opening, generally hemispherically shaped openings in said second layer, said openings extending inwardly through said second and first layers to communicate with generally planar openings in said first surface,

said hemispherically shaped openings in said second surface being interconnected to facilitate the flow of ink thereacross, while said generally planar openings of said first surface are unconnected to substantially prevent ink flow thereacross.

2. A screen printing stencil as set forth in claim 1, wherein said first surface is characterized by a rectangular crosswork of elongated, continuous intersecting segments to present said grid pattern, and said second surface is characterized by a plurality of posts opposite the points of intersection of said segments of material, said posts being generally diamond-shaped in cross-section.

3. A screen printing stencil as set forth in claim 1, wherein said first and second layers are composed of different metals.

4. A screen printing stencil as set forth in claim 3, wherein said first layer is composed of nickel, and said second ink-applying surface is composed of copper.

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