Oct. 27, 1970 S. W. OTTO ET AL 3,535,955

FLAT AND ROTARY DIE CUT DIES

Filed Feb. 21. 1968 2 Sheets-Sheet 1

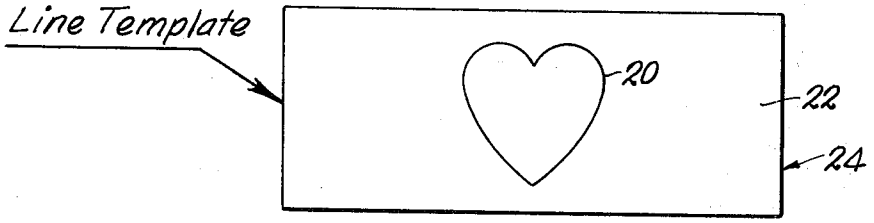


Fig. 1.

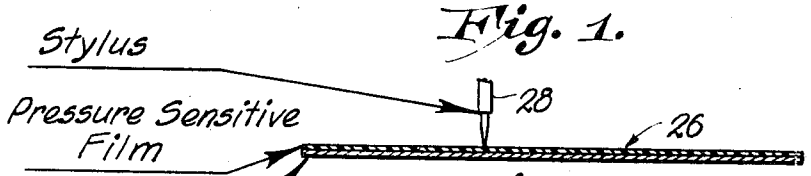


Fig. 2.

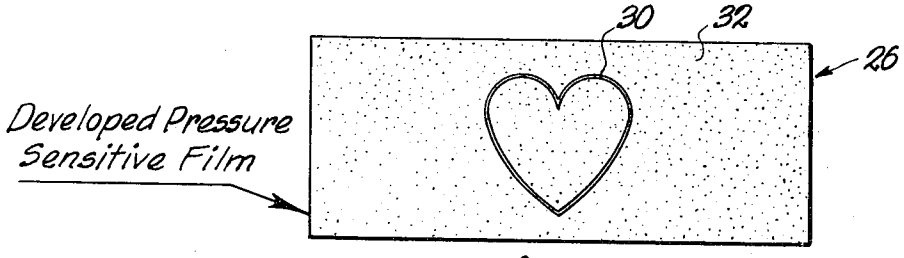


Fig. 3.

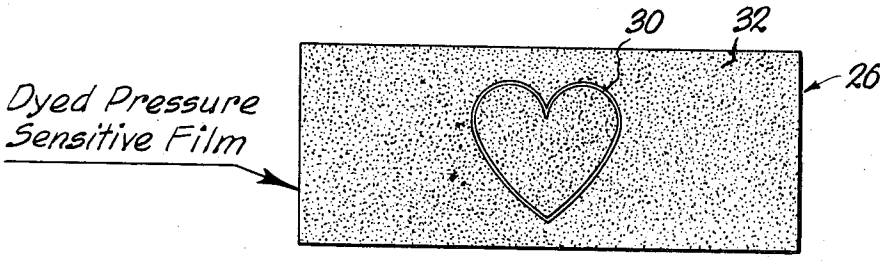


Fig. 4.

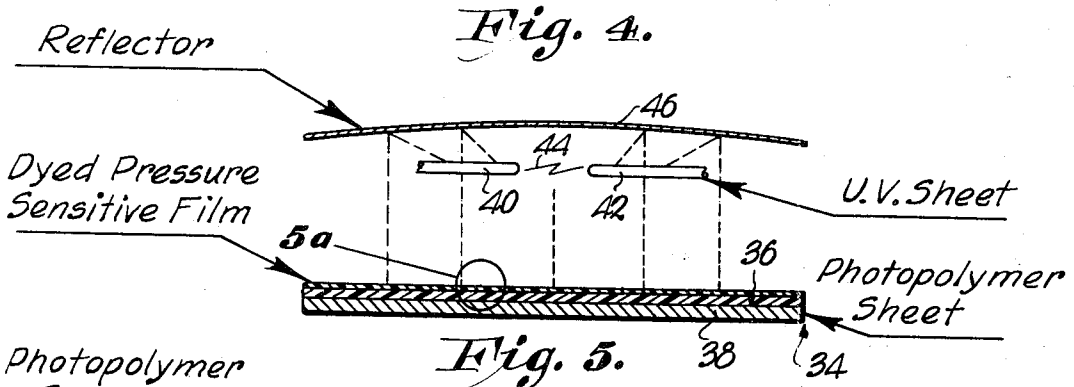


Fig. 5.

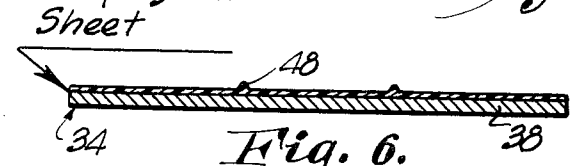


Fig. 6.

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FLAT AND ROTARY DIE CUT DIES

Filed Feb. 21, 1968 2 Sheets-Sheet 2

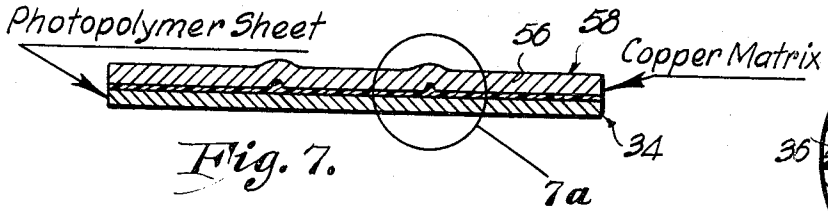


Fig. 7.

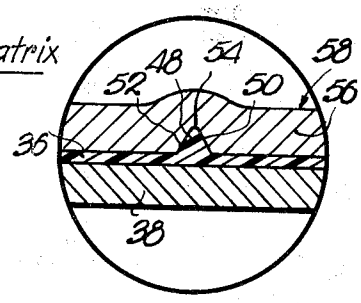


Fig. 7a.

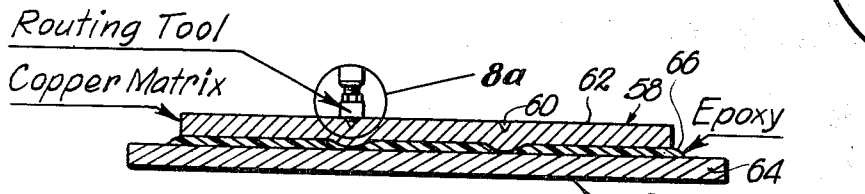


Fig. 8.

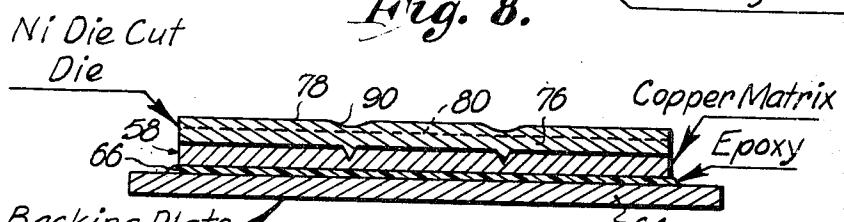


Fig. 9.

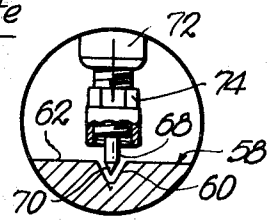


Fig. 8a.

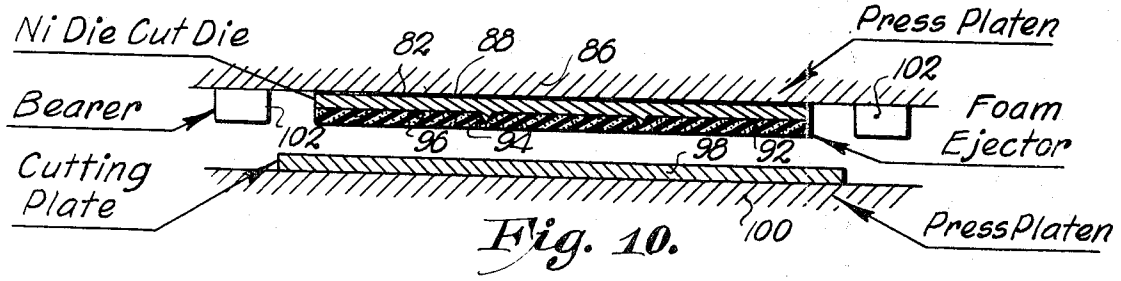


Fig. 10.

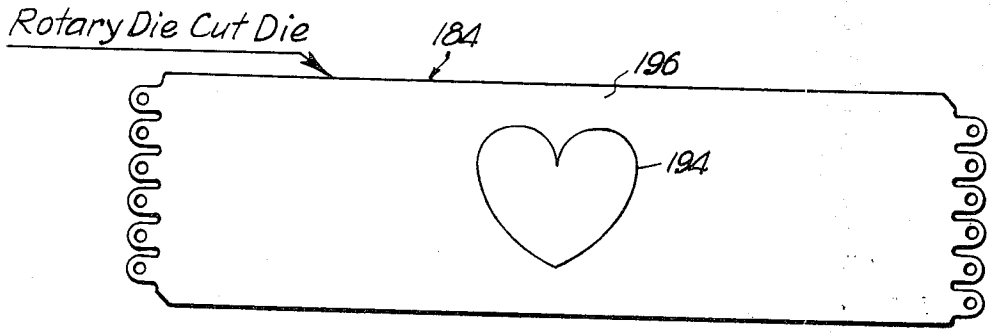


Fig. 11.

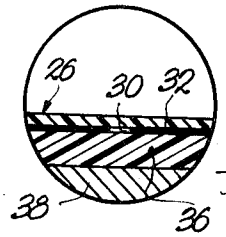


Fig. 5a.

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3,535,955

FLAT AND ROTARY DIE CUT DIES

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Int. Cl. G03c 5/00
U.S. Cl. 76—107 8 Claims

ABSTRACT OF THE DISCLOSURE

A method of preparing flat and rotary die cut dies from a line drawing of a design. An outline of the line design is made on pressure-sensitive film, which upon development is used as a mask over a sheet of metal plate-backed photosensitive material during exposure thereof. The line defining area of the photosensitive material which is hardened during exposure of the sheet presents a rib projecting from the backing plate upon development of the material. A copper matrix is electro-formed against the developed photosensitive sheet and the grooves formed in the matrix are routed with a V-shaped cutting tool. A layer of Ni is then electro-formed against the routed copper matrix to form the die cut die.

This invention relates to the field of graphic arts and especially processes and apparatus which significantly improve the preparation of rotary and flat die cut dies used to cut relatively intricate patterns in various materials such as paper, plastic, or thin metal sheets.

It has long been known that the appearance and visual effect of many printed designs, especially on paper stock, or thin sheets of metal or plastic, may be enhanced by the cutting out of an outline of the design so as to emphasize the peripheral edge of the artistic impression on the sheet. The art in this area has become very highly developed in connection with the production of greeting cards, calendars, paper party goods, decorative wrapping, and decorative accessories, with the quality of the die cut margin and its alignment with the printed design area being especially critical because of the normally relatively close visual observation which is made of the design by a recipient or purchaser of the item.

Heretofore, the die cut operations have been carried out in two major ways, all of which have been time-consuming and expensive insofar as the tooling is concerned. Flat die cut dies have for the most part been made by first preparing a line drawing of the outline of the design to be die cut followed by securing of the line drawing to a sheet of plywood approximately ¾' in thickness. A highly skilled worker than utilizes a jigsaw to cut through the plywood along the line of the design to be cut. Next, another workman, using the cut plywood as a guide, prepares a bent steel rule of configuration which will fit into the groove formed in the plywood by the jigsaw. A hand-operated bender having a fixed, generally V-shaped mandrel and a shiftable pointed bending force is used to bend the steel rule transversely thereof in a manner to reproduce the line design image formed in the sawed plywood. Frequently, it is necessary to employ modified hand-tools in the nature of pliers to produce bends in the rule of relatively narrow radius. The bent steel rule is then inserted in the plywood and secured therein so that the sharp edge thereof projects above the surface of the wood. Thus, upon mounting of the assembly on a supporting plate, it is ready for use in a press.

It can be appreciated that this procedure not only is extremely time-consuming but of necessity, involves highly skilled workers who must spend a long time in apprenticeship before mastering the technique of preparing a satisfactory die cut die, at least insofar as the more intricate shapes are concerned.

A second type and the other major procedure for preparing dies involves the utilization of tools to machine the surface of a wear-resistant metal plate so as to form sharp ribs projecting from the major plane of the plate which serve as cutters to cut the stock against which the die cut die is forced. In this instance, it is the usual practice to leave a portion of the surface of the machined die to serve as a bearer. Machining operations may be used to fabricate either flat or rotary die cut dies and, in fact, is the only generally satisfactory method now available for the preparation of rotary cutting dies.

It is, therefore, the primary object of this invention to provide a method of constructing die cut dies of either the rotary or flat type which substantially eliminates the manual fabrication operations and attendant dependence on skilled workmen which have been requisites of prior machining and steel rule bending fabrication techniques.

It is a further important object of the invention to provide a method of preparing rotary or flat die cut dies which permits reproduction of a line design utilizing electroforming processes so that much of the laborious manual efforts heretofore involved are obviated in permitting the use of less skilled personnel without sacrificing the quality of the cutter and, in fact, permitting a more accurate reproduction of the design than has heretofore been possible of achievement except only with very painstaking and expensive procedures.

Another very important object of the invention is to provide a method of fabricating a flat or rotary die cut die in a shorter period of time than has heretofore been possible and a lower cost by virtue of the utilization of a technique of transferring the design from one reproduction to another without loss in configuration thereof by virtue of the fact that the original design to be die cut in line form is traced onto a pressure-sensitive film to form a clear area thereon corresponding to the design and which thereby presents a mask through which a photosensitive material carried by a metal plate is exposed and then developed so that only those areas which are hardened by the exposure process and which correspond to the design remain after development of the photosensitive material and thereby permitting forming of a matrix against the developed photosensitive material which presents a female of the die so that the die may be formed directly against the matrix. In this connection, a subsidiary object of the invention is to provide a technique as described wherein the cutting edge defining rib of the die is relatively sharp at the apex thereof without secondary machining or other treatment being required because of the fact that the grooves in the matrix are routed out with a V-shaped tool prior to forming of the die therefrom and thus assuring that the cutting edge ribs in the die are truly V-shape in cross section and of uniform height throughout the extent of the die.

Also an important object of the invention is to provide a method of preparing flat or rotary die cut dies which lends itself to high volume operations by virtue of the fact that as many dies as may be needed can be prepared, either at one time or as the demand therefor arises, and also permits fabrication of such dies on a production line basis where various individuals do specific jobs in preparation of the die.

An object of the invention is also to provide a procedure for preparing die cut dies which is adaptable without significant change for the fabrication of either flat or rotary dies by virtue of the fact that the forming techniques are the same in both instances with the only difference being the utilization of an optically distorted line drawing as the starting template for rotary die cut dies.

In the drawings:

FIG. 1 is a plan view of a line template usually comprising a sheet of paper having a line representation thereon of the design to be die cut;

FIG. 2 is a vertical cross-sectional, schematic representation of a sheet of pressure-sensitive film overlying the design sheet of FIG. 1 and illustrating the way in which a stylus is employed to develop the film to provide an outline of the design;

FIG. 3 is a plan view of the developed film as illustrated in FIG. 2;

FIG. 4 is a plan view of the film as illustrated in FIG. 3 after dyeing of the opaque areas thereof;

FIG. 5 is a vertical cross-sectional, schematic representation of the dyed film of FIG. 4 used as a mask in overlying relationship to a sheet of photosensitive material supported by a backing plate and illustrating a typical way in which the photosensitive material is exposed to a source of energy rays through the mask;

FIG. 5*a* is an enlarged view of the circled portion of FIG. 5;

FIG. 6 is a vertical cross-sectional view through the photosensitive material after development thereof to remove the portions of the material which remain unhardened after exposure to the source of energy rays;

FIG. 7 is a vertical cross-sectional, schematic showing of the developed photosensitive material backed by a metal plate and illustrating the way in which a metal matrix is electroformed against the developed face of the photosensitive material;

FIG. 7*a* is an enlarged view of the circled portion of the laminate illustrated in FIG. 7;

FIG. 8 is a vertical cross-sectional, schematic representation showing the way in which a routing tool is employed to route out the bottom of the grooves formed in the metal matrix illustrated in FIG. 7, and with a metal plate being used to support the matrix during the routing operation;

FIG. 8*a* is an enlarged view of the circled portion of FIG. 8;

FIG. 9 is a vertical cross-sectional, schematic showing of the way in which a nickel die is electroformed against the matrix while supported by a metal plate;

FIG. 10 is a vertical cross-sectional, schematic showing of the way in which the nickel die shown in FIG. 9 and supported by a backing member may be mounted on the platen of a press and ejector material secured to the cutting face of the die; and

FIG. 11 is a plan view of an electroformed nickel die adapted to be secured to a rotary cylinder and illustrating the way in which the cutting rib is optically distorted for use on a rotary press.

In accordance with the preferred procedure of the invention, a line drawing **20** is prepared on a sheet of paper **22** to present a line template **24**. In this instance, it is assumed that a flat die cut die is to be prepared and thus the outline **20** is of the exact shape of the area to be cut out of a sheet of material such as thin metal, plastic, or paper stock.

Next, a sheet of pressure-sensitive film **26** is placed over the design sheet or line template **24** while the latter is supported on a planar surface such as a light table permitting viewing of the line design **20** through film **26**. The pressure-sensitive film **26** is preferably of the type having a transparent synthetic resin backing element provided with a coating thereover presenting a large number of discrete, relatively small, pressure-rupturable cells. Upon rupture of the cells, the translucent or generally opaque coating is destroyed to an extent whereby the transparent backup element is fully exposed on both sides thereof for unimpeded viewing therethrough. Referring to FIG. 2, the film **26** is positioned on template **24** in disposition such that the rupturable coating lays against the upper face of the design sheet. A particularly useful pressure-sensitive film for the present purpose is manufactured and distributed by the Photo Products Department of E. I. du Pont de Nemours & Co., Wilmington, Del., and sold under the trademark Cronapress.

A stylus is then used to develop the film by tracing along the outline of design **20** with sufficient pressure to effect rupture of the individual cells of the coating on the film directly under the point of the stylus. Since it is desirable to form as fine a line as possible in the film, the tip of the stylus should be sufficiently pointed to make only a very fine line without cutting the upper surface of the film. Best results are obtained utilizing a stylus having a somewhat rounded point having a diameter of about 0.001.

The developed pressure-sensitive film is illustrated in FIG. 3 wherein it can be seen that the clear section **30** surrounded by the translucent portion **32** conforms to and is of the exact same shape of line design **20**. Next, the film **26** is successively subjected to densifier and stabilizer solutions which render the remaining emulsion part **32** of film **26** opaque. Suitable densifier and stabilizer solutions are also distributed by Du Pont under the Cronapress designation. These materials turn the unruptured part of the emulsion **32** a dark blue opaque color which is stabilized by application of the stabilizer solution to the dyed surface.

The dyed film **26** is placed over a photopolymer sheet **34** having a layer of photosensitive material **36** supported on and firmly affixed to a metal backing plate **38**. A preferred photopolymer sheet is manufactured and distributed by E. I. Du Pont de Nemours & Co., Wilmington, Del., under the trademark Dycril. U.S. Pat. No. 3,306,745 describes a photopolymer sheet of a usable type in the present process. Dycril is particularly advantageous because the layer of photosensitive material **36** is of a thickness sufficient to provide a cutting rib of desired height on the final die as will be explained. Normally, the thickness of the photosensitive layer **36** will be around 0.025.

The laminate illustrated in FIG. 5 comprising the dyed pressure-sensitive film **26** overlying sheet **34** is then exposed to a source of ultraviolet rays preferably constructed so as to direct such rays through the film **26** onto material **36** in substantially perpendicular relationship to the planar surface of the assembly as illustrated in FIG. 5. In this instance, the spaced electrodes **40** and **42** which produce an arc **44** are positioned in front of a reflector **46** which serves to direct the ultraviolet rays onto the photosensitive material **36** through the clear section **30** of film **26** in essentially straight lines. It is to be appreciated that in actual practice, the ultraviolet source will be spaced a considerable greater distance away from the photopolymer sheet **34** than is indicated only schematically in FIG. 5.

Those parts of sheet **34** directly underlying the clear section **30** of film **26** and which are thereby exposed to the ultraviolet rays from the arc **44**, are caused to undergo further polymerization and thereby harden while the areas of sheet **34** directly under the opaque portion **32** remain essentially unhardened and may be removed by a conventional alkaline wash solution distributed by Du Pont in connection with its Dycril material.

FIG. 6 illustrates the photopolymer sheet **34** after development thereof with an alkaline wash solution as described whereby the unhardened portions of the material **36** are washed away by the solution leaving only the hardened or polymerized design defining ribs **48** in the surface of material **36** facing away from plate **38**.

In this connection, it is to be understood that a part of the material **36** affixed directly to plate **38** is sufficiently hardened during processing of the original photopolymer sheet to render the same resistant to being washed away by the development solution so that even after the washing operation a thin layer of the photopolymer material remains on plate **38** as illustrated in FIG. 6. In addition, and as best shown in FIG. 7*a*, the design defining rib **48** projecting from the modeled surface of the photopolymer sheet **34** is defined by a pair of diverging wall surfaces **50**

and **52** which merge with the remaining layer of photosensitive material **36** on plate **38**. The outer extremity of rib **48** which is represented by a somewhat flat margin **54** in FIG. *7a*, is of a transverse width substantially equal to the width of the design defining section **30** of developed film **26**. However, the thickness of the rib **48** transversely thereof between margin **54** and the remaining layer of photosensitive material **36** increases as the plate **38** is approached because of the fact that even though the ultraviolet rays from arc **44** are directed onto the laminate of FIG. 5 in substantially straight lines perpendicular to the planar surfaces thereof, the energy rays passing through clear section **30** and penetrating the layer of material **36** strike the upper face of plate **38** and are reflected back into the photopolymer material. As a consequence, an area of the photopolymer material which is essentially trapezoidal in cross section is caused to undergo further polymerization and is of the shape best shown in FIG. *7a*. This phenomenon is important to the present process since it assures production of a final die wherein the cutting rib assumes substantially the shape of rib **48** and is thus of sufficient structural integrity to withstand the wear encounted in long-run die cutting operations.

Next, the modeled surface of the photopolymer sheet **34** is coated with a parting agent which is electrically conductive [e.g., colloidal or precipitated silver] and a layer **56** of copper is electroformed against the coated surface of photopolymer sheet **34**. The layer of copper thereby defines a matrix **58** which is essentially a female of the developed photopolymer sheet **34**. As best shown in FIG. *7a*, the matrix **58** thereby has grooves **60** in one face **62** thereof which correspond with ribs **48** of photopolymer sheet **34**. Because of the fact that the lower part of each of the grooves **60** is also somewhat flat because of the conformation to margin **54** of rib **48**, it is desirable that the grooves **60** to be routed with a V-shaped cutting tool to cause the grooves to be truly V-shaped in cross section and of uniform depth throughout the extent thereof.

Before carrying out the routing operation however, it is desirable to mount the copper matrix **58** on a steel backing plate **64** through the use of a suitable adhesive such as an epoxy resin **66**. Securing of the matrix **58** to plate **64** is carried out so that the planar surfaces of the members are maintained in parallel relationship and with the face **62** facing upwardly as shown in FIG. 8.

The routing of matrix **58** is preferably carried out by utilization of a cutting tool **68** having a V-shaped cutting edge **70** and which is rotatable in a spindle sleeve **72** provided with an adjustable depth-limiting cylinder **74** on the lower extremity thereof. It is to be appreciated that the spindle sleeve **72** is carried by the support therefor in such a manner that, although being movable vertically, the axis of tool **68** is maintained exactly perpendicular to the face **62** of matrix **58**. Furthermore, the cylinder **74** is adjustable on sleeve **72** so that upon engagement of the lower circular edge of cylinder **74** with the face **62** of matrix **58**, the cutting edge **70** of tool **68** is received in groove **60** such that the angled edges of the tool are exactly parallel with the inclined walls defining the respective portions of grooves **60**. In this way, not only is the groove **60** routed out so that it is of precise V-shaped configuration, but the depth of such groove is uniform throughout the extent of the matrix. The tool holder may form a part of a milling machine so that the operator can control the movement thereof across the matrix face **62**, or in the alternative, a milling pantograph used wherein the stylus thereof is moved along the design **20** of sheet **24** or in a sheet of material having an intaglio relief therein defining design **20**.

After routing of the matrix **58**, a parting agent which is electrically conductive as noted above is placed over the face **62** thereof in covering relationship thereto and a layer **76** of nickel electrodeposited against the copper **56** as best shown in FIG. 9. Upon removal of the electroformed layers **76** from matrix **58**, the back portion

78 thereof is machined to the level **80** illustrated by dotted lines in FIG. 9 so that the remaining back face **82** of the nickel **76** is essentially flat and parallel with the front face of the nickel. The member thus presented comprises a nickel die **84** which is adapted to be mounted on press platen **86** using a contact adhesive **88**. The extent of milling or machining of the back portion of nickel layer **76** is determined by the depth of the grooves **90** which are formed in the electrodeposited nickel during electroforming thereof. The milling should be carried out to a sufficient extent to cause the remaining back face **82** of die **84** to be flat.

Foam material **92** may be affixed to the cutting face of die **84** and preferably is slightly higher than the cutting ribs **94** projecting from the face **96** of die **84** so that when the latter is brought down into engagement with the cutting plate **98** on lower press platen **100**, the ejector material **92** will serve to displace the cut stock from die **84**.

The ribs **94** projecting from face **96** of die **84** have a sharp outer cutting edge and such edge not only conforms exactly to the design **20** but is of also uniform height above the level of face **96**. Bearers **102** which are a conventional part of a die cutting machine serve to limit the extent of reciprocation of die **84** toward cutting plate **98**.

Although the preferred process described above suggests electroforming of matrix **58** against the developed photopolymer sheet **34** followed by electroforming of the nickel die **84** against matrix **58**, it is to be understood that various techniques may be effected for fabrication of these components. For example, a phenolic synthetic resin matrix may be molded against sheet **34** and the nickel die **84** then electroformed against the synthetic resin matrix. Alternatively, the die **84** may be formed by gas plating techniques utilizing nickel tetracarbonyl $Ni(CO)_4$ as the composition from which the nickel is deposited. Similarly, gas plating may be used to form matrix **58**.

The present process is equally adaptable for preparation of rotary die cut dies, although the specific steps thus far set forth have related specifically to the fabrication of a flat die cut die **84**. The principal additional steps required involve photographically reproducing the line template **24** so that the line design **20** thereon is optically distorted in a known manner so that when the design is reproduced on a member which is adapted to be wrapped around a cylinder forming a part of a rotary press, the design cutout of a flat sheet passed therebetween will conform to the original design **20** rather than be distorted. In addition, the nickel layer **76**, gas plated or electroformed against matrix **58**, should be of a thickness lending the same to be bent around a cylinder of a rotary press without cracking. In this respect, the rear surface of the electroformed or gas plated nickel may be backed up with a suitable material or machined away as necessary to provide a flat rear face. A typical, initially flat die cut die is illustrated in FIG. 11 and designated by the numeral **184**, with it being noted that the rib **194** projecting from the face **196** thereof is optically distorted with reference to the design **20** so that when the die **184** is wrapped around a cylinder, there will be no distortion of the design cut in the stock passed between the die and a backing cylinder. Furthermore, the opposed ends of die **184** are blanked and pierced as indicated to facilitate mounting of the cutting member on the rotary machine.

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

1. A method of constructing a die cut die having a rib portion projecting from one surface thereof and presenting a cutting edge conforming to the shape of a line design, said method including the steps of:

preparing a mask for use against a sheet of photosensitive material, said mask having an area which is substantially opaque to energy rays capable of

effecting hardening of the photosensitive material, and a line defining section within said area capable of permitting passage of said energy rays therethrough and conforming to the configuration of said design;

positioning the mask over the sheet of said photosensitive material wherein the latter is of a thickness exceeding that of the stock to be cut with said die and of a depth at least approximately equal to the height of the rib desired in the final die cut die;

exposing the assembly of said sheet and the mask to said energy rays for a period sufficient to effect hardening of the transversely trapezoidal line defining portions of the photosensitive material underlying said section of the mask;

developing the exposed sheet to remove the unhardened portions thereof;

fabricating a matrix of the developed sheet and having design defining grooves in the face thereof against the sheet of photosensitive material; and

electroforming a layer of wear resistant metal over the matrix to form said die.

2. A method as set forth in claim **1**, wherein is included the step of routing out the bottom of the design defining grooves in said matrix to cause the inner part of each of the grooves to be of substantially V-shaped configuration.

3. A method as set forth in claim **2**, wherein said routing of the matrix includes the steps of passing a tool along said grooves having a V-shaped cutting edge, and maintaining the tool at a predetermined depth in said grooves during movement thereof.

4. A method as set forth in claim **1**, wherein preparation of the mask includes the steps of placing a pressure-sensitive film on a support therefor, said film having the characteristics of normally being substantially nontransparent but subject to being converted to transparent form in those areas where pressure is applied thereto while support is provided for such film, and applying sufficient force to said film to effect conversion thereof along a line substantially conforming to the shape of said design.

5. A method as set forth in claim **4**, wherein is included the step of applying said line defining force to a film comprising a transparent backing element provided with a coating on one face thereof having a large number of relatively small, pressure rupturable cells therein.

6. A method as set forth in claim **5**, wherein is included the step of placing a pointed tool against the coated surface of said element and moving such tool across the coated surface with sufficient force being applied thereto to effect rupture of said cells in a pattern presenting said design.

7. A method as set forth in claim **4**, wherein is included the step of dyeing the remaining nontransparent portions of the film to present said opaque area thereof.

8. A method as set forth in claim **4**, wherein is included the steps of preparing a line drawing of said design, placing the pressure-sensitive film over the line drawing, providing a generally planar support for the drawing and said film, and tracing the outline of the design on the film by placing a pointed tool against the film at a point in overlying relationship to the design followed by movement of the tool across the film under sufficient pressure to effect conversion of the film.

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U.S. Cl. X.R.

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