Dec. 23, 1952 A. A. HEATH 2,622,516

DUPLICATING STENCIL MATRIX

Filed April 13, 1950

Fig. 1.

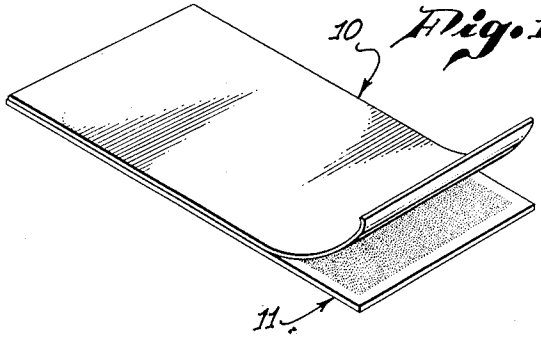



Fig. 2.

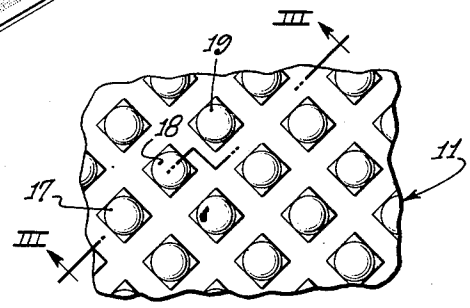



Fig. 4.

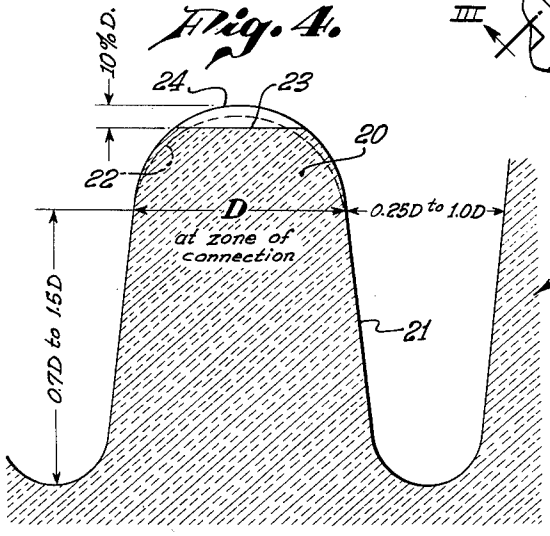



Fig. 3.

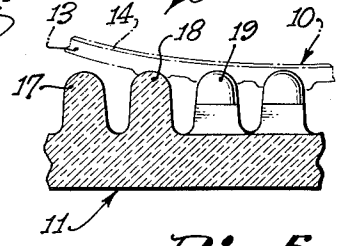



Fig. 5.

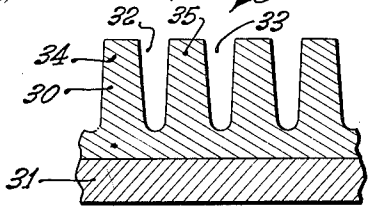
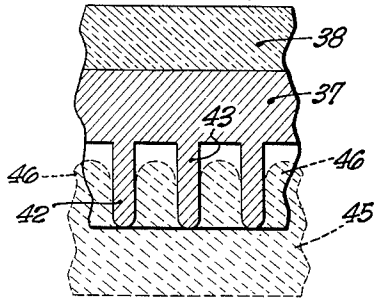



Fig. 6.




ALMON A. HEATH,
INVENTOR.

BY C. Q. Wiebe

ATTORNEY.

Patented Dec. 23, 1952 2,622,516

# UNITED STATES PATENT OFFICE

2,622,516

## DUPLICATING STENCIL MATRIX

Almon A. Heath, Inglewood, Calif., assignor of one-half to William B. Collins, Inglewood, Calif.

Application April 13, 1950, Serial No. 155,727

3 Claims. (Cl. 101—128.4)

1

This invention pertains to a new, novel and improved matrix for use in preparing duplicating stencils, whereby solid, shaded and half-tone effects can be attained.

Duplicating stencil sheets are well known in the art. These stencil sheets are made with a base of very porous, tenuous, fibrous tissue covered with a friable or waxy and oily coating. Yoshino paper (which is a very loosely felted and tenuous material) has been often used as a base for the displaceable coating, the total thickness of the stencil sheet being 0.002, 0.0025, or 0.003 inch. The coating normally prevents the passage of printing ink through the stencil sheet. When a stencil is made or cut, this coating is removed or displaced along the lines representing the character or design being cut. The cut stencils are used upon a hollow, revolving drum or cylinder partially covered with an ink pad. The stencil sheet is normally stretched over the surface of the drum with the positive, readable side facing the ink pad. Ink passing through the character or design cut in the stencil is deposited upon the paper and makes the desired impression.

Because of the tenuous and delicate character of the stencil sheet base, and in an attempt to prevent injury or damage to such base, instead of applying a stylus directly to the duplicating stencil sheet, it has been suggested that an additional thin, tenuous, preferably transparent sheet of material be placed over the duplicating stencil, the overlying sheet or film being made from a material which serves as a fluent medium to transmit pressure from a stylus to the stencil sheet (see for example, Patents No. 1,989,922 and No. 2,203,280). This expedient has certain disadvantages, and one of the objects of the present invention is to eliminate the cover sheet.

It is to be remembered that after a duplicating stencil has been cut it must be firmly applied to the hollow, revolving, inking cylinder or drum. The duplicating stencil is under tension, and when the duplicating machine is hand or motor driven, the stencil is subject to considerable tension and wear. As a result, many stencils break while in use. This breakage is primarily due to the fact that during the cutting of the stencil the fibers of the filmy base of the duplicating stencil sheet have been cut or broken and the strength of the sheet materially decreased or virtually destroyed. This is particularly true when the duplicating stencil has been used in the preparation of line drawings, breaks generally occurring along lines formed on the sheet by a

2

stylus. When it is necessary, for example, to make clear, continuous lines, considerable pressure is applied to the stylus in order to make certain that all of the waxy or friable coating is properly displaced or removed from the coated side of the duplicating stencil sheet and such procedure generally results in the destruction of sufficient fibers of the base to greatly reduce the life of the stencil.

In an attempt to ameliorate the destructive effect of a stylus upon the strength of a stencil, roughened or etched sheets have been introduced beneath the duplicating stencils during stencil cutting, and although such roughened sheets have a tendency to hold the stencil sheet in position they do not prevent the material loss in the strength of the stencil sheet.

The fact remains that heretofore it has not been practical to cut stencils with continuous lines nor to produce on a stencil, solid, halftone and freehand shaded effects. In order to produce a solid area (as, for example, the shadows on an object being depicted) considerable pressure had to be employed and it was impossible to remove or displace the coating with sufficient thoroughness, without destroying the tissue framework to result in a solid area when the stencil was used in making an impression.

It is also to be noted that whereas some stencil coatings are suited for typing work, such coatings are too tough for use with a stylus for hand art work; and soft coatings suitable for hand-cut line drawings are too soft for cutting with type and loop letters are frequently completely cut out. As a result, art work and typing of good quality cannot be placed on the same sheet with satisfactory results. The present invention permits art work (composed of line and solid effects) to be formed on the same stencil with typed matter, both forms being capable of reproduction in a satisfactory and acceptable manner.

The present invention is directed to an improved type of matrix which can be inserted beneath a duplicating stencil sheet, said matrix permitting solid, shaded and halftone effects to be produced upon the stencil by the use of normal, pointed styli and without the necessity of using wheels, loops and other devices. Moreover, the improved matrix of the present invention permits these effects to be obtained without destroying the strength of the duplicating stencil and as a result, the stencils may be used on reproducing devices for protracted periods of time without impairment.

Generally stated, the matrix of the present in-

vention comprises a sheet of resilient, organic, thermoplastic composition, the surface of the sheet bearing between 12,000 and 15,000 spaced, identical, displacement pips, paps, papilla or mamelon per square inch. The shape of these pips is extremely important. They have been designed to displace and move the stencil coating away from a desired area without cutting or destroying the strength of the tenuous, filamentary base which carries the displaceable coating. The head of each pip is virtually hemispherical and convex and therefore does not pierce the stencil sheet.

The cross-sectional area of the pips (in a zone of maximum diameter of the pips) should comprise between about 20% and 40% of the total area of the sheet, in order to produce permeable depressions in the waxy coating which are in sufficient proximity to permit the ink passing through adjacent depressions to form a continuous line upon the paper during reproduction without destroying the tenuous base of the stencil sheet. Other characteristics and specifications regarding the arrangement, construction and size of the pips will become apparent from the more detailed description given hereinafter.

It is an object of the present invention, therefore, to disclose and provide an improved matrix for use in preparing duplicating stencils for producing solid, shaded and halftone effects as well as lines, type etc.

A further object of the invention is to disclose and provide an improved matrix for use in preparing duplicating stencils whereby the mechanical strength of the stencil is not destroyed or materially reduced.

An object is to provide means whereby type as well as art work may be formed in a stencil sheet provided with a displaced coating, both type and art work being reproducible in a highly acceptable manner.

A still further object of the invention is to disclose the limitations, conditions and specifications for an improved matrix.

These and other advantages of the invention will become apparent from the more detailed description appearing hereinafter and from a contemplation of the appended drawings, in which:

Fig. 1 is a perspective view illustrating the relationship between the improved matrix of the present invention and a duplicating stencil, in use.

Fig. 2 is an enlarged plan view of a small portion of the surface of the improved matrix.

Fig. 3 is an enlarged section taken along the plane III—III of Fig. 2.

Fig. 4 is a greatly enlarged section, through a representative pip, illustrating the important relationships which give rise to the improved results attained by this invention.

Fig. 5 and Fig. 6 illustrate one manner in which a matrix sheet of the character herein described can be manufactured.

When it is desired to cut a stencil or prepare a duplicating sheet for use on a duplicating machine, such sheet, generally indicated at **10**, will be placed upon a matrix **11**, the upper surface of the matrix being provided with a multiplicity of upstanding pips. This entire assemblage may be supported on a translucent plate (illuminated from below) so that a design or other drawing upon a translucent sheet of paper may be interposed between the matrix **11** and the source of light in order to guide the operator in cutting his stencil.



The stencil sheet **10** is generally applied to the matrix **11** with the coated waxy side resting upon the pips and the upper surface (including the tenuous fibrous base of the duplicating stencil sheet) may, if desired, be covered with a very thin, smooth surfaced, transparent sheet of material through which pressure from the stylus may be transmitted to the stencil sheet. The stylus may be then used in delineating the desired character, object, drawing, or the like, styli of various sizes being used in accordance with the character of line or effect desired. Straight edges or other drawing instruments may be employed or freehand effect can be obtained.

The matrix **11**, to which this invention is drawn, is best illustrated in Figs. 2 and 3, Fig. 2 being a fragmentary enlarged plan view, whereas Fig. 3 is a section through pips **17** and **18** and a side view of pip **19**. The number, arrangement and contour of the pips are critical. In the first place, it is necessary to have between 12,000 and 15,000 displacement pips per square inch (although 17,000 to 20,000 per sq. in. can be employed). Secondly, each of the pips should be provided with a virtually hemispherical or rounded convex head, whereby the displaceable coating, indicated at **13** in Fig. 3, which is carried by the tenuous base **14** of the duplicating stencil sheet, can be displaced by the pips during cutting or formation of the stencil without puncturing, destroying or impairing the strength of the sheet **10**. The displacing effect of a rounded pip of the character herein referred to is illustrated in Fig. 3.

Another requirement is that the width between the pips and the depth of the spaces between the pips be adequate to receive the waxy material which is displaced on the surface of stencil sheet **10**. It may be generally stated that each of the pips must be provided with a hemispherical head mounted upon a post, said posts having an average height of 0.7–1.5 times the diameter of the pips at their zone of connection with the posts. It has been found that when these relationships are followed the matrix displaces the coating material in a satisfactory manner and the coating does not clog the spaces between pips so that uniform action results even though a matrix is employed for a considerable length of time. The cross-sectional area of the pips in a zone of connection with the posts should be between about 20% and 40% of the total area of the sheet: this assures adequate spacing between the pips and again permits the waxy material of the duplicating stencil sheet to flow into the spaces during cutting of a stencil and form concave depressions in the stencil sheet, which depressions subsequently act as receptacles or pools for ink.

By referring to Fig. 4, the various relationships generally referred to can be readily observed. The head of the pip is indicated at **20** and the post is indicated at **21**. The convex heads of the various pips **20** are all tangent to a common plane. The zone of connection between the pip head and its post lies in a plane parallel to the plane tangent to all of the apices of the pip heads and the maximum diameter of each pip head is shown as being in such zone of connection, such zone of connection and maximum pip diameter being indicated at D. In order to make certain that the sum of the transverse cross-sectional areas of the pip heads (in such zone of connection) comprises between about 20% and 40% of the total area of the sheet, the minimum spac-

ing between adjacent pips (when they are arranged in a regular pattern as in Fig. 2) should vary from 0.25D to 1.0D, as indicated in Fig. 4. In order to make certain that there is adequate space between the pips, the depth of the grooves between adjacent pips should be between 0.7D and 1.5D. The maximum diameter of the pip head is used as a criterion since, as previously indicated, there should be between 12,000 and 22,500 pips per square inch, which is equivalent to between about 110 and 125 pips per lineal inch. Maximum pip diameter is therefore on the order of 0.004–0.0046 inch.

The contour of the head of the pip is of prime importance. At no event should this pip head be sharply pointed, since sharply pointed pips puncture the duplicating stencil sheet and destroy its strength. The term "virtually hemispherical" as used herein in describing the pip heads is not limited to a mathematically accurate hemispherical head, but includes convex heads of a contour capable of smoothly and easily displacing the waxy material on a stencil sheet without puncturing the same. For example, although the head of pip **20** illustrated in Fig. 4 is indicated in solid lines as a true hemisphere, such head may assume the geoid or parabolic or ellipsoidal form indicated by dash lines at **22**. At all events, the transverse cross-sectional area of a pip head, in a plane located at a distance from its apex of 10% of the maximum pip diameter, should be more than 15% and not more than 75% of the area of the pip in a plane at the zone of connection. In Fig. 4 the plane indicated at **23** is at a distance from the apex **24** which is equal to 10%D; the cross-sectional area in plane **23** (when the pip head is hemispherical) actually amounts to about 38% of the cross-sectional area of a pip head having a diameter D.

By reason of the convex head a slight penetration of a pip into the stencil sheet under light stylus pressure, results in a relatively large concave impression in the duplicating stencil sheet. If for example, a pip penetrates into the waxy coating of a stencil sheet a distance equal to only 6.25%D, the area of the resulting impression is equal to 25% of the cross-sectional area of the pip at its maximum diameter D. When the pip head penetrates into the waxy coating a distance equal to 12.5%D, the area of the depression thus formed constitutes 47.2% of the cross-sectional area of the pip head at its maximum diameter. Similarly, penetration of the pip head to a distance equal to 25% of D, the cross sectional area of the resulting cup-shaped depression equals 76.5% of the maximum area of the pip head.

An artist working on a stencil sheet with the aid of a matrix of this invention can controllably obtain various desired effects by use of heavy or light stylus pressure, pressure variations producing specific changes in size of depressions. It will be evident, therefore, that it is virtually impossible to destroy the tenuous, fibrous base **14** of the duplicating stencil sheet since the waxy material will flow over the rounded surface of a pip head and an adequate ink-receiving depression will be made in the stencil without breakage or destruction of the stencil sheet. It has been found that when the curvature of the outer surface of a pip head is controlled so that the transverse cross-sectional area, at a plane located at a distance from its apex of 10% of the maximum pip diameter, is more than 15% but less than 75% of the area of the pip at the zone of connection, cutting of the fibers is prevented, smooth displacement of the waxy material is assured and solid effects, as well as half tones, can be obtained when the matrix is used in cutting stencils.

It has been determined that the range of pips per square inch hereinabove referred to, the spacing of said pips, the rounded head configuration and the depth between pips are factors correlated to the thickness of the stencil and the flowable inks used in duplicating machines, and produce a control over the passage of ink through the stencil, which control has not been attained before. Uniformity in printing results from such correlation, in addition to the variety of effects obtainable and the increased strength and enhanced longevity of the stencil.

Tests conducted under controlled conditions using commercial duplicating stencil sheets cut under identical stylus pressure conditions definitely show that the use of the matrix of this invention does not reduce the strength of the duplicating stencil appreciably.

For example, a batch of duplicating stencil sheets was tested by scribing transverse lines thereon with a stylus weighted to 265 grams. A part of the stencil sheets were so scribed using the matrix of this invention, while another and equal number of sheets were scribed using the same stylus and weight but employing a rough-surfaced stylus plate manufactured and sold by A. B. Dick Company. Still another number of sheets from the same batch were left unscribed. Tensile tests were conducted on all sheets with the following results: sheets cut on the A. B. Dick plate lost 56% of their original tensile strength, whereas sheets cut on applicant's matrix lost only 22% of their original tensile strength. It is to be remembered that in addition to the remarkable strength, applicant's stencil sheets produce cleaner, denser and more uniform lines upon being used in duplication printing.

The matrix herein described can be made in a number of different ways. Extensive experimental work has conclusively shown that in order to produce an effective matrix the material constituting the matrix should be tough, have dimensional stability under varying conditions of humidity, have considerable mechanical strength, be unattacked by the waxy components of the duplicating stencil, and have a surface to which the waxy material will not tenaciously adhere. Cellulose acetate, cellulose butyrate, cellulose nitrate and methyl methacrylate are exemplary materials which are eminently suited for use in the matrix.

The matrix of this invention may be readily manufactured from any of the thermoplastic materials mentioned hereinabove by first cutting or milling a dummy (illustrated in section in Fig. 5) from a sheet of metal. Although any relatively soft metal can be used, it has been found desirable to employ a heavy silver deposit **30** upon a rigid metal base **31** and to mill grooves **32**, **33** and the like therein, said grooves being of a width equal to the spacing between adjacent pips. Grooves such as **32**, and **33** are made at right angles to each other, the spacing between grooves being equivalent to the maximum pip diameter. Such milling of grooves will leave upstanding bosses such as **34** and **35**, square in plan. These bosses should be higher than the total height of the pip head and posts. The grooves **32**, **33** and the like are therefore on the order of 2–2½D. Milling or scribing of the grooves **32**

and 33 in a heavy silverplate is preferred since smooth surfaces are readily attained, although other easily workable metals can be used.

After the dummy has been made, a die is formed by casting a relatively low-temperature alloy over the dummy or by electroplating. When withdrawn from the dummy, the low melting-point alloy or electroplated member forms the die 37 which may be bonded to a strong, rigid base 33, the assembly of the die 37 and rigid support 38 being then used in manufacturing matrices from a thermoplastic sheet material. The thermoplastic, in sheet form, may be preheated (to a temperature at which the sheet is formable) and the die 37 then impressed thereinto. It will be understood that the die 37 is, in effect, a series of rectangular depressions separated by relatively thin walls, such as the walls 42 and 43. When these walls are impressed into the plastic (indicated at 45), the plastic flows and pips such as 46 are formed, the upper surface of each pip assuming a rounded, virtually hemispherical form. The depth of penetration of the die 37 into the plastic sheet 45 is controlled so as to incompletely fill the spaces between the partitions or webs 42, 43 with the plastic. The thermoplastic sheet which is thus impressed to form a matrix may be thin and flexible or it may be 0.2 or 0.3 inch thick and sufficiently strong to act as a direct substitute for the ground glass used in a Mimeoscope (trade name). Although the method described has been successfully used in the manufacture of these matrices, other methods may also be employed. It is to be understood that the pips are preferably arranged in rows at an angle, say 45°, to the longitudinal edges of the matrix and stencil sheet to be superimposed thereon.

The matrix of this invention may be used in other ways than that specifically described hereinabove. For example, the stencil sheet may be laid over the matrix with the coated side up, then covered with a thin, tough, pressure transmitting sheet or film, and the desired design traced or worked on such thin sheet or film, pressure from the stylus causing the coating to be pressed down into the backing of the stencil sheet and form protrusions in such backing, while the originally coated side is relatively smooth and flat. The thin, superimposed film prevents the stylus from plowing into the coating.

All changes and modifications coming within the scope of the appended claims are embraced thereby.

I claim:

1. An improved matrix for use in preparing duplicating stencils for producing solid, shaded and halftone effects, comprising: a sheet of resilient, organic thermoplastic, one surface at least bearing between 12,000 and 17,000 spaced, identical displacement pips per square inch, each of said pips being provided with a virtually hemispherical, convex head supported upon a slightly tapering post, the convex heads of said pips being tangent to a common plane parallel to the plane of the sheet; the depth of spaces separating the pips comprising from about 0.7 to 1.5 times the average diameter of a pip at a zone of connection of a pip with its post; said pips being separated from each other, in said zone of connection, by a distance of from about 0.25 to 1.0 times the average diameter of a pip at such zone of connection, the aggregate cross-sectional area of the pips in such zone of connection comprising between 20% and 40% of the total area of the sheet.

2. An improved matrix for use in preparing duplicating stencils for producing solid, shaded and halftone effects, comprising: a sheet of resilient, organic thermoplastic, one surface at least bearing between 12,000 and 17,000 spaced, identical displacement pips per square inch, each of said pips being provided with a virtually hemispherical, convex head supported upon a slightly tapering post, the convex heads of said pips being tangent to a common plane parallel to the plane of the sheet; the aggregate cross-sectional area of the pips in a zone of connection with the posts comprising between about 20% and 40% of the total area of the sheet; each pip head having, at a plane located at a distance from the apex of 10% of the average pip diameter at said zone of connection, a cross-sectional area of more than 15% but less than 75% of the area of the pip at said zone of connection, the pips being separated from each other, in said zone of connection, by a distance of not less than 25% nor more than 100% of the average diameter of a pip at said zone of connection, the depth of the spaces separating the pips comprising about 70% to 150% of said average diameter.

3. An improved matrix for use in preparing duplicating stencils for producing solid, shaded and halftone effects, comprising: a sheet of resilient, organic thermoplastic, one surface at least bearing between 12,000 and 20,000 spaced, identical displacement pips per square inch, each of said pips being provided with a virtually hemispherical, convex head supported upon a slightly tapering post, the convex heads of said pips being tangent to a common plane parallel to the plane of the sheet; the aggregate cross sectional area of the pips in a zone of connection with the posts comprising between about 20% and 40% of the total area of the sheet; the pips being separated from each other, in said zone of connection, by a distance of not less than 25% nor more than 100% of the average diameter of a pip at said zone of connection, the depth of the spaces separating the pips comprising about 70% to 150% of said average diameter.

ALMON A. HEATH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,989,922 | Heath | Feb. 5, 1935 |
| 2,106,481 | Giles | Jan. 25, 1938 |
| 2,185,924 | Pereira | Jan. 2, 1940 |
| 2,241,441 | Bandur | May 31, 1941 |
| 2,303,198 | Cunnington | Nov. 24, 1942 |

FOREIGN PATENTS

| Number | Country | Date |
|---|---|---|
| 244,228 | Great Britain | Dec. 17, 1925 |