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UNIVERSITY OF LOUISVILLE

NEWSPAPER MATRIX BACKING TECHNIQUES
"

A Thesis

**Submitted to the Faculty
of the Graduate School
of the University of Louisville
in Partial Fulfillment
of the Requirements
for the Degree of**

MASTER OF CHEMICAL ENGINEERING

Department of Chemical Engineering

Robert Roscoe Childs
///

June, 1949

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NEWSPAPER MATRIX BACKING TECHNIQUES

Robert Roscoe Childs

Approved by the Examining Committee.

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June, 1949

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ABSTRACT

The problem of developing suitable materials and techniques for the elimination of hand backing of mats was undertaken. A thermosetting resin of the resorcinol type, admixed with 15 to 25 per cent short-fiber asbestos, was applied to the mats both as a paste and in the form of a partially cured resin sheet. Its use was discontinued since its inherent insulating properties and warpage were found to be undesirable.

After experimenting with several other backing materials and methods, the following procedure was concluded to be feasible:

- (1) Spraying sodium silicate solution upon a sheet of blotting paper.
- (2) Pressing the glue-coated blotting paper to the mat during the pressing of the mat upon the chase.
- (3) Warming to set the glue.
- (4) Sanding excess blotting paper off high portion of mat back.
- (5) Final drying in "Sta-hi" vacuum driers.

A sanding unit was designed and constructed to remove the backing from the raised portions of the mat.

In an effort to replace the present day dry mat with one requiring no backing, the following materials were chosen and tried as mat substitutes: Aluminum sheet, lead-aluminum laminates, Teflon, ethyl cellulose, resorcinol, and several layers of the moistened, conventional mat.

INTRODUCTION

Before a description is made of the operations in the preparation of a newspaper which primarily concern the topic of this thesis, a brief outline of the steps employed in preparing the newspaper is presented to lend perspective to the problem.

The various articles, news items, stories, etc. are typed upon a linotype machine, a device which automatically casts one line or slug of metal type at a time. The type is set and an inked reproduction of the original article is made upon a small sheet of unsized paper. This reproduction is then compared with the original article or copy. If the two are not identical, the copy is sent to the linotype machine for corrections.

Next, columns of slugs are placed in a metal support or chase approximately the size of a newspaper page, together with photo engravings and advertisements. The type is then locked securely in place and the chase frame is ready for stereotyping.

The first step in this process is securing an accurate mold of the type. A paper matrix or mat large enough to cover the type completely is placed upon the chase, and a cork blanket is placed upon the mat. This assembly is then pressed in either a roller or a direct pressure molding machine resulting in an accurate impression of the type in the mat. The mats are taken to a table where backing is applied and then placed

in Sta-hi formers. This machine, a vacuum drier, forms and dries the mat in the proper curved shape. At this stage the mat shrinks from 3/8 inch to 1 inch depending upon the character of the mat and the initial moisture content. When a mat is taken from the former, it is placed in a curved oven at approximately the temperature of the molten type metal.

The hot, dried mat is then placed in a semi-cylindrical casting box which conforms to the curvature of the printing rolls, and molten type alloy is poured against the surface of the mat. The casting is broken away from the mat and trimmed of excess metal, cooled, and machined for attachment to the presses.

Since the dry mat is used as a mold in casting the printing plates, it must be smooth, moldable, strong, pliable, uniform in thickness and construction, and capable of withstanding molten type metal at 600°-700° F. It should be capable of free release from the type metal casting and should possess the property of shrinking uniformly.

The printing quality of the plate is determined by the molding property of the mat which should be strong and clear. The mat should have sufficient strength to preserve the impression for prolonged exposures since oftentimes 3 or 4 castings must be made from it, and it should be pliable enough to be shaped to the proper contour. It should have sufficient stability to remain pliable during and after the casting.

Its insulating value should be low enough to prevent unfavorable crystallization of the alloy or cold spots upon the surface of the casting. A high heat conductivity permits the mat to utilize the cooling action of the shell of the casting box. If the metal cools slowly the cast may show a leaf like crystalline structure known as flake that reproduces on the paper in the subsequent printing.

After it is molded, the mat is backed, an operation considered indispensable although many mats have been tried reputedly requiring no backing. At present gummed paper felt strips are placed on the back of the mat in open spaces or spaces which have not been indented by molding. This filling prevents high spots of the mat from indenting during the casting. Any undue movement of the impressed sections of the mat may produce smudges or streaks on the printed page.

The time required for the backing of each mat was considered excessive and a search for new materials and methods of backing was considered as the first phase of this study. If a mat could be developed requiring no backing, the problem would be greatly simplified and this realization led to another phase of the investigation, namely, the development of a mat, either by modification of the existing paper mat or by the use of an entirely different material, which would be satisfactory in the casting operation and would successfully resist the pressure of the molten type metal as well as the temperature.

HISTORICAL

The first cast stereotype plate was developed by William Ged of Scotland in 1730 using plaster of paris molds and casting with lead. However, his method was unsatisfactory as were others developed in the 18th century and it was not until the beginning of the 19th century that the possibilities of stereotyping came into recognition.

The Earl of Stanhope, Charles A. Mahan, improved the existing methods to such an extent that stereotyping became practical. He locked one or more pages in a chase frame and oiled the type to prevent sticking. Plaster of paris in a semi-fluid condition was poured upon the surface of the type and allowed to harden. It was then placed in an oven and baked for several hours. When the mold was baked, it was put in a casting pan and metal was poured into the pan until it covered the plaster of paris. This operation resulted in a thin solid plate about 1-1/6 in. thick. Although impressions taken from plaster of paris molds were claimed to be excellent, they had many disadvantages including inconvenience in manipulation, slow processing, and uselessness for more than one impression.

In July, 1829, a French printer named Genoux developed a method which is still used in some localities. Several layers of paper were stacked one upon the other using a mastic as binder. The combination of layers was placed upon type forms, and a roller was used to make impressions in the

matrix. It was then dried, and a cardboard frame was pasted around the back of the matrix in order to give more depth to the face of the type. This mat was placed between two iron plates, and metal was poured through a large aperture in one of them thereby obtaining the casting. This wet or papier-mache mat underwent numerous changes and improvements with the use of different pastes, but the procedure was essentially the same for years.

Just as deficiencies of the plaster of paris process led to the invention of the papier-mache process of stereotyping, so did the drawbacks of the latter make the invention of a new process a necessity. The actual quality of work done using the wet mat could hardly be improved and stereotypers directed their activity toward finding a material which would produce the same high quality results but would avoid the many drawbacks encountered with wet mats. For instance, it was not possible to prepare the mat far in advance of the time it was actually needed since the pastes had a tendency to mold and sour. Also, uneven pasting as well as fermentation of the paste caused the mat to blister or blow up when molten metal was poured against it.

The invention of the dry mat was credited to George Eastwood in 1887. This mat retained certain features of the wet mat and was designed for molding by rolling only once in contact with the chase.

In 1899 another inventor developed a mat designed to eliminate backing. Schimansky (Germany) obtained a patent on a mat consisting of vegetable fibers artificially rendered porous so that the impressions of the type to be stereotyped took place by destroying the porosity at the pressed parts, thereby rendering the mold directly suitable for casting. Schimansky suggested all types of vegetable fibers including wood cellulose, hemp, cotton, or flax. He produced a porosity in the mat by first immersing it in a sodium carbonate solution and then in an acid such as vinegar, releasing carbon dioxide which tends to swell the mat. It was then coated with a paste of glycerin in starch to prevent metal from adhering to it.

Neither the Eastwood nor the Schimansky mat possessed a surface which could be impressed sufficiently without tearing the fibers nor were they firm enough to withstand the pressure of molten metal at the blank spaces of the type, especially on repeated casting. The texture of the paper mat itself appeared on the casting. After considerable modification and improvement the Schimansky mat was manufactured.

Although neither Eastwood's nor Schimansky's inventions were satisfactory in a commercial sense, a large number of paper manufacturers experimented with dry mat manufacturing, finally developing the present day product.

Since Schimansky's time many attempts have been made to develop mats which would eliminate backing entirely.

However, all of them have had serious drawbacks, such as poor shrinkage characteristics and excessive hardness causing shallow impressions. All of these experimental mats depended upon the addition of lithopen resins, astringent chemicals, filling earths, and special adhesives.

The present day dry mats are homogeneous units delivered in sheet form of standard size, 20 in. x 24 in. They are made of any thickness between the limits of 0.02 in. and 0.04 in. to meet the preferences and needs of stereotypers. They are not laminated and hence do not blow up and blister, nor do they deteriorate.

However, these mats are affected by humidity change and must be protected by means of water vapor-tight containers and stored in special rooms of constant humidity. Upon absorption of moisture, the mat swells, and, conversely, upon drying, it shrinks through loss of moisture. When dry mats were first made in the United States they were a failure because of uncontrolled dimensional changes.

The German mat was used for a short time in this country but was abandoned because of its undependable shrinkage causing some pages to be long and narrow and others to be short and wide. It was found that the dry mat shrank in one direction with respect to its method of manufacture, and the stereotyper could rely on that shrinkage if he knew how the mats had been cut. It occurred to the stereotyper that he

could get from $\frac{1}{4}$ to $\frac{3}{4}$ inch shrinkage across the width of the newspaper page and that this shrinkage would affect a great savings in newsprint if properly controlled. Today, shrinkage in a mat properly moistened and manufactured is reasonably constant over the entire width of the page, and can be accurately controlled. The ratio of shrinkage in width to shrinkage in length is 2:1 with most of today's mats.

At first, backing came in large sheets of felt, which were cut into strips covered with a paste and applied where needed. Later on, the felt was delivered covered with paste, and then it became the practice to sell the gummed felt in all sizes as desired.

Many machines and devices have been constructed to apply the backing in an attempt to reduce the time required for this operation. However, all of them were complicated and expensive and could not compete with the accuracy of hand backing. Accordingly, the hand backing of mats has continued to the present.*

* Goggin, "Manual of Stereotyping." Kable Brothers Company, Mt. Morris, Ill., 1935.

Kubler, "A New History of Stereotyping." J. J. Little and Ives Company, New York, N. Y., 1941.

EXPERIMENTAL

The nature of the experimental work involved in this research was such that it can be divided into the following four main groups:

1. Resins for matrix backing.
2. Porous sheet backing for the matrix.
3. New mat materials.
4. Alteration of the matrix for color work.

The experimental procedure, as well as the discussion of results, is considered separately for each group.

A. RESINS FOR MATRIX BACKING.

A number of possibilities for the solution of this problem were available. However, the line of attack selected for initial investigation was the use of a synthetic resin to be applied to the back of the dried mat and then cured to a hardness and stiffness sufficient to prevent indentation during casting. A variation also selected for study was the application of the backing materials before the drying of the mat although, in general, it was considered that a resin treatment after drying would be the more satisfactory.

These concepts led to a number of questions answerable only with detailed information on resins and experimental results of the behavior of these resins under actual or simulated operating conditions. Accordingly, a survey was made of properties of both thermoplastic and thermosetting resins (1), (2), (3), (4).

In brief, the thermosetting resins can be expected to withstand the higher temperatures and remain hard, while the thermoplastic resins melt at elevated temperatures (5). The literature also was examined for reportings of fillers (6), (7), extenders, modifiers, and plasticizers (8), (9) so that methods of modifying the properties of selected materials would be available for subsequent experimental work.

A quick-setting resorcinol-formaldehyde resin was selected for the initial trials. This resin was prepared by the Resinous Products and Chemical Company of Philadelphia and is sold under the trade name of Amberlite PR-115, with its catalyst, P-117. In addition, several extenders or fillers such as short fiber asbestos, cotton linters, wood flour and methyl and ethyl cellulose were used as plasticizers.

Preliminary experiments with the resin, using a mixture of 100 parts of PR-115 to 15 parts of P-117, by weight, showed that it could be cured to a hard and brittle condition in 5 minutes at a temperature of 100° C. Its adhesion qualities, when applied to paper, were excellent; however, it caused the paper to warp as a result of non-uniform shrinkage.

Small mat samples 4 inches square were prepared, and resin mixtures containing varying amounts of wood flour as a filler were applied to one side of each sample. It was found that the cured resin increased in hardness with an in-

crease in wood flour content. Above 10 per cent flour the mixture was too viscous for easy application to the back of the mat. Also, it was observed that warpage of the mat was greater when the wood flour was admixed with the resin.

Next, resin mixtures containing short fiber asbestos were examined and found to increase slightly in pliability with increase in asbestos content. Those mixtures containing from 15 to 25 per cent asbestos gave satisfactory results, although some warping of samples of the backed mats was still observed. Five minute cures at 100°C were used and a hard brittle backing was obtained. Therefore, it was concluded that, in trials with backing materials of this type, curing of the mat in approximately the curvature necessary for the casting machines would be desirable.

Work with cotton linters as a constituent of the resin mixture gave poor results in that considerable warpage was found as well as high viscosities of the mixture with relatively low cotton contents.

Plasticization of the resin mixture with methyl cellulose was ineffective in producing a pliable and non-warp backing, and it was decided to control the character of the mixture by means of the amount of filler or extender employed.

Because of the favorable results with the asbestos-resin mixtures and the possibility of some control of the properties of the cured backing by the amount of filler added,

it was decided to employ this material in subsequent experiments.

For the investigation of the behavior of the experimental backing mixtures under conditions similar to those encountered in the casting machines, a small casting device was designed and constructed (Fig. 1). The apparatus consisted of a one inch pipe 30 inches long, the lower end of which was fitted with a 4 inch coupling. The upper end was equipped with a 2 inch by 1 inch reducing coupling to serve as a funnel. This column was mounted with the 4 inch coupling in contact with a small section of the backed mat which, in turn, was in contact with a water cooled steel plate. Gas burners were arranged to maintain the pipe and fittings at a high enough temperature to prevent solidification of the type metal.

When molten metal 600-650°F. was poured into the column, the small sections of the backed mats were subjected to liquid metal pressure equivalent to that in the commercial units. Experiments of this nature did not damage the backing resins even though, on several occasions, the type metal was hot enough to scorch the mat.

The use of infra-red heating as a curing procedure for the resin was next considered. A resin composition containing 15% asbestos was spread upon small samples of mat and these samples were placed beneath a single infra-red lamp. The height of the lamp above the sample was varied from 20 to

FIG. 1. CASTING APPARATUS

24 inches and the time for complete cure was 15 minutes with slight blistering in each case.

This procedure was repeated using a resin composition containing 25 per cent asbestos and the lamp height was varied from 15 to 20 inches. Complete cures were obtained in 10 minutes with very little blistering.

The single infra-red bulb was replaced by a bank of infra-red heating elements and samples of the latter resin composition were placed beneath it and cured. Again, all samples blistered slightly although the curing time was reduced to 5 minutes.

Since the surface of the resin was exposed directly to the lamps, Kraft paper was placed upon the uncured resin samples prior to their subjection to infra-red radiation in an effort to eliminate entirely or at least reduce blistering. Cures were obtained in 3 minutes; however, some samples blistered and others did not.

Because of the inherent stiffness of the cured resin, it was considered desirable to cure the resin-backed mats in approximately that curvature necessary for the casting machines. For this purpose, a semi-cylindrical drier was designed and constructed (See Fig. 2). Essentially, this unit consisted of two semi-cylindrical pieces of sheet metal enclosing resistance wire. A doctor blade was adapted to the unit so that the resin mixture could be spread uniformly over

FIG. 2. SEMICYLINDRICAL DRIER

the curved mat. The connection of the resistance wire to an electrical source permitted the heating of the resistance wire and, in turn, the sheet metal and the resin-backed mat.

After completing the construction of the unit and appropriate adjustments to give reasonably uniform temperatures at the metal surface in contact with the mat, experiments with the resin backing of full-size mats were undertaken. It was found that resin mixture containing 25 per cent asbestos could be cured upon the drier in 10 minutes without blistering as long as the resin mixture was uniformly applied. As the thickness of resin coating was increased, the effect of shrinkage was also increased. However, some difficulty was encountered in uniformly spreading the 25 per cent asbestos mixture, and methanol was added to lower the viscosity of the resin mixture to a more workable consistency.

In an effort to reduce the curing time of the resin-backing below 10 minutes and simultaneously provide a non-adherent surface for the back of the mat, a sheet of Kraft paper was applied to the uncured mat backing. This technique permitted the use of higher curing temperatures with little or no resin blistering and noticeably reduced warpage of the backed mat.

The possibility of drying and curing the resin backed mat in a single operation was considered since this procedure would decrease the overall time for processing the mat. Al-

though some difficulty was anticipated with this process because of blistering of the mat itself, no such difficulties were experienced. Damp mat samples were coated with resin and placed in an oven where the mat was dried and the resin cured. The sample was then clamped in the casting apparatus and molten metal was poured upon it. Accordingly, these tests with the damp mats were repeated several times in an effort to produce blistering of the mat. However, in none of these tests could a blistering of the mat be produced.

Since the five minute cures were considered too long and since blistering occurred if the temperature were raised high enough for shorter cures, a possible solution was the use of pressure in conjunction with the heating. For this purpose a small laboratory press (6 in. platens) was used and experiments undertaken to observe the curing times under a variety of temperature and pressure conditions.

Partially cured sheets of resorcinol resin were prepared by applying a thin coating of the resin to 6 inch by 6 inch sheets of Kraft paper and allowing them to stand at room temperature for varying lengths of time. The sheets were placed upon the back of the mat and then inserted in the cold press. If the pre-cure time were two hours or more, the resin did not adhere well to the mat. But using cold press platens and a pressure of 2000 pounds on a $1\frac{1}{2}$ inch ram, the overall curing time was not shortened materially.

Other experiments were carried out using heated press platens and the results were more encouraging. Six inch squares of resin coated paper which were pre-cured were pressed onto mats at pressures of 5000 lbs. using platen temperatures of 180° to 180°C . Curing times as low as 15 seconds were observed with excellent adhesion even with a three hour pre-cure of the resin coated paper at room temperature.

Although this hot pressing procedure gave a smooth, hard backing to the mat, a number of inherent difficulties were recognized, i.e., the resin tended to deform large portions of the mat which did not require backing such as half tones or advertisements. The backed mats were stiff and possibly too stiff for bending to fit the casting machines.

To eliminate these undesirable features a variation of the method was used consisting of applying the resin coated paper to the mat after pressing, but while still on the chase.

Because of the relatively low total loads obtainable with the laboratory press, it was necessary to use very small mat samples in these latter tests. For this purpose a small chase (4 in. x 4 in.) was constructed and mats and backing materials reduced proportionally. The small mat samples were impressed, the resin coated paper applied and

pressed onto the mat at very low pressures for 5 to 15 seconds. Final curing was accomplished in a drier. The total curing time, using this technique, was two minutes; and a perfectly backed mat was obtained.

The possibility of applying the resin coated paper to the mat, pressing and, finally, curing in a drier was investigated and found to give a good backing. Although this method gave good results with small samples, there was some doubt as to its practicability with full size mats. To investigate further this somewhat simplified procedure, arrangements were made to carry out some preliminary plant tests. A large sheet of Kraft paper (20 in. x 24 in.) was coated with resin and partially cured for one hour at room temperature. This sheet was applied to the back of a full-sized, damp newspaper mat and the assembly pressed in the molding machine. Curing was accomplished in the Sta-hi driers at the usual operating conditions producing some blistering of the resin and warping of the mat. A casting from this mat revealed additional difficulties: the resin prevented uniform drying of the mat proper.

In another test a resin-coated sheet of Kraft paper was applied to a dry, impressed mat and cured in the Sta-hi without vacuum. Again blistering occurred because of the high temperature of the drier (250° F). However, a more satisfactorily backed mat was obtained even though

warpage was excessive.

Because of the inherent hardness and brittleness of the cured resin, a typical plasticizer, tri-cresyl phosphate, was obtained and mixed with the uncured resin in varying concentrations. However, no noticeable change in the pliability of the resin was observed.

Because of the need for resin coated paper in the experimental procedure under investigation, preliminary tests with commercial sheet resin (Tego) were made. This material was somewhat slower than the resoreinol resin heretofore employed and required approximately 200°F. for curing on the mat.

A quick and simple method of applying resin to the back of mats was considered, and it was decided that the spraying of the resin mixture with an ordinary paint spray gun would be satisfactory. In order to do this the resin had to be thinned considerably with a suitable solvent and the filler (asbestos) eliminated.

Liquid PR-115 was diluted with methanol and catalyst added in the proper proportion. A mat was clamped to the semi-cylindrical drier, the latter being re-wired and mounted vertically for this experiment. The drier was then heated and the resin mixture sprayed onto the hot mat. The resin required 15-20% methanol to give a suitable consistency for spraying.

With the drier arranged in the above manner, it was found that the heating was not uniform and that blistering occurred in some portions of the mat and not in others. The drier was then mounted horizontally in a cradle and could be rotated in a half circle by means of a pulley arrangement. A thermocouple traverse was taken across the surface of the drier and the positions of the heating elements were adjusted to give a uniform temperature distribution.

With the mat temperature at 200°F the time for curing the resin was 3 to 5 minutes; however, the resin remained tacky for some time afterwards. Also, it was found that only a very thin film of resin could be applied at one spraying since it tended to flow if large quantities were sprayed. It was possible to allow the first coating to become tacky before applying a second coat, but this obviously increased the overall time for the operation to such an extent that it could hardly be considered. However, only one coat of resin would not provide enough support as a backing medium. In fact, 3 or 4 coats were found to be too flexible to support the metal.

Methanol was used because of its relatively high volatility since it was believed that the time of cure could be reduced if the solvent evaporated quickly. However, the curing time was found to be 5 minutes.

The next solvent tried was water. The character-

istics of the sprayed resin, using water as solvent, were similar to those when using methanol. If temperatures above 210⁰F were used for curing, the resin blistered. Adhesion was excellent, but warpage was considerable.

One of the disadvantages of spraying resin onto the mat was that there was considerable loss. All mats used in these experiments were weighed before and after spraying. The resin container also was weighed before and after spraying. In this manner it was possible to determine the amount of resin actually sprayed that was deposited on the mat surface and, from this, the percentage loss. The results are shown in Table III.

Several dry mats were sprayed, each with a different, but known, amount of resin, and taken to the Courier-Times Building for plant tests.

It was observed on the castings, that the backing was sufficiently stiff for relatively narrow portions of the mat. In order to determine a correlation between the distance from the edge of a backed portion of the mat and the amount of depression made by the metal, a traverse was taken across various portions of the casting where backing was required, and the distances were measured.

In order to decrease warpage of the mat and to prevent water from entering into the mat proper, a waterproof material was sprayed onto the mat prior to the application of

the resin. The first material to be tried was a vinyl resin. This proved to be highly successful in preventing absorption of moisture by the mat; however, the resin did not adhere well to the vinyl coating. Coatings of Buna N rubber and zinc stearate were sprayed onto the mat separately; and, although the moisture did not penetrate, warping occurred since the adhesion of resin to the coating was excellent.

Since it was found that the best casting was obtained from the mat containing the least resin, the possibility of glueing a satisfactory material onto a mat upon which a thin layer of resin had been sprayed was considered next. The following materials were applied to the back of the mat: sawdust, glasswool, cotton linters, and blotting paper. After the glue had hardened, the backing material was sanded down to a level with the high portions of the mat leaving the low portions filled or backed. Of these four materials, blotting paper was most satisfactory.

Because the resorcinol-spray mixture was so thin, the blotting paper acted as a filter and allowed penetration of the resin, giving a poor bond between the blotting paper backing and the mat. To eliminate this difficulty, the blotting paper was first sized with the resorcinol mixture and allowed to cure. Then it was again sprayed with resin, applied to the back of the smooth, unpressed mat and the linotype pressed into the mat in the usual manner. The mat was then

placed on a drier where the moisture was removed and shrinkage took place.

In order to improve the evaporation of moisture from the mat, small holes were drilled into the mat backing at regular intervals. Trials were made to establish a suitable combination of hole diameter and spacing in order to provide a satisfactory backing and yet permit free moisture evaporation. The pattern found to be most satisfactory is shown in Fig. 3.

A number of procedures and materials then were tried using full size mats and perforated blotting paper as follows:

(1) Resorcinol first was sprayed as a sizing material and cured; mat was sprayed with resorcinol and blotter was pressed onto the mat.

(2) Same procedure as (1) except that the resorcinol was sprayed onto the sized blotter instead of mat prior to pressing.

(3) Tego film was sprayed with water (on both sides) and was placed between blotter and mat and the assembly pressed.

(4) Blotter was sized with a water solution of mucilage. Mucilage was then sprayed onto the blotter which, in turn, was pressed to the mat.

(5) A second mat was used as backing material with latex as the bonding medium.

FIG. 8

ARRANGEMENT OF HOLES IN SECTION OF BLOTTING PAPER

(6) Water glass (sodium silicate solution) was used as bonding material.

All these mats were pressed onto the linotype using the same pressures that are used at the Courier-Times plant. Following the pressing operation, the mats were dried at a temperature of approximately 250°F for 20 minutes.

B. POROUS SHEET BACKING FOR MATRIX.

The success with these experiments led to the establishment of a tentative procedure as follows: (1) preparation of perforated sheet to cover entire back of mat, (2) application of perforated sheet to mat back when mat is pressed, (3) drying of mat in conventional manner, (4) sanding of dried mat to remove backing from high spots, and (5) casting molten type metal upon surface of mat. The individual steps carried out with small and near full size samples indicated promise for the procedure. Therefore, a sander was designed and built to carry out step (4).

Experiments with blotting paper backing were continued with the completion of the sanding machine shown in Fig. 4. When the mat was pressed with the perforated blotting paper in place, circular indentations were observed in the mat at positions corresponding with the position of the perforations. Therefore, the possibility of using a continuous sheet of blotting paper or one with a larger number of

Fig. 4 Sanding Machine

Without Compression roll, guards and guides.

very small holes was considered.

If a continuous sheet is used for the mat backing, evaporation of moisture from the mat is hindered. Therefore, to make a comparison of evaporation rates a plain, unbacked mat was pressed and dried. Samples of the mat were cut at different times during the drying process and moisture determinations made. The same procedure was followed using two more mats at different initial moisture contents backed with continuous sheets of blotting paper glued to the mat with a thin solution of sodium silicate. The data are given in Table I.

It was found that mats containing a large amount of open work warped a great deal and, as a result, were not uniformly sanded. In order to keep a constant pressure of the mat against the sanding roll, a sheet of sponge rubber was glued to the surface of the steel drum. In addition, a compression roll was added to guide and hold the mat in place on the drum just prior to contact with the sanding roll. The compression roll offered a number of advantages, the most important being the more uniform smoothing of the mat before sanding and the possibility of operating without clamping the mat to the metal drum. Mats processed in this fashion were considered generally satisfactory but local warpage of the mat during preliminary air drying made adjustment of the proper

TABLE I. COMPARISON OF DRYING TIMES OF MATS
WITH AND WITHOUT BACKING.

	<u>Without Backing</u>			
Drying Time (min.)	15	30	60	120
Wt. wet sample (gms.)	7.651	8.851	8.345	10.883
Wt. dry sample (gms.)	7.375	8.781	8.287	10.827
Wt. moisture (gms.)	0.276	0.070	0.058	0.056

	<u>With Backing-1</u>			
Drying Time (min.)	15	30	60	120
Wt. wet sample (gms.)	9.619	7.867	9.490	10.077
Wt. dry sample (gms.)	9.053	7.546	9.321	9.960
Wt. moisture (gms.)	0.566	0.321	0.169	0.117

	<u>With Backing-2</u>			
Drying Time (min.)	15	30	60	120
Wt. wet sample (gms.)	11.011	11.789	9.061	8.925
Wt. dry sample (gms.)	10.024	11.146	8.839	8.746
Wt. Moisture (gms.)	0.987	0.643	0.222	0.179

clearance between the large roll and the sanding roll difficult. Figs. 5 and 6 show both the continuous and the perforated blotting paper backing after it had been glued upon the mat and dried, while Figs. 7 and 8 show the mat after the blotting paper had been removed from the high spots by sanding.

Although the unit as shown was satisfactory for experimental work, the following additions or modifications were added so that the unit can be used for plant tests:

1. Provision of a satisfactory mechanism for advancing and withdrawing the drum to and from the sanding roll.
2. Preparation of a suitable device for holding sandpaper to the sanding roll.
3. Installation of suitable guards and covers for moving parts.
4. Installation of suitable guides to permit proper feeding and removal of mats.
5. Provision of dust collector.

The sanding roll was driven by a $1/3$ H.P. motor in such a way that the roll could be turned at 3 different speeds: 1420 R.P.M., 2750 R.P.M. and 5000 R.P.M. The completed sanding machine is shown in Fig. 9.

The mat to be sanded was placed face down upon the large drum which was rotated forwards and backwards past the sanding roll by means of a crank on the shaft of the drum. The drum was advanced or withdrawn from the sanding roll by

Fig. 5 Continuous Backing Before Sanding

Fig. 6 Perforated Backing Before Sanding

Fig. 7 Perforated Backing After Sanding

Fig. 8 Finished Mat

FIG. 9 SANDING MACHINE

means of a screw adjustment (Fig. 10), thereby making it possible to remove any desired amount of backing. A sheet metal guard was placed around the sanding roll in order to trap the dust and direct it past the blower and thence to the collecting bag.

C. NEW MAT MATERIALS.

A survey of available printed matter on materials thought suitable for mats was made (10), (11), (12), (13), (14), (15), resulting in the conclusion that, if mat shrinkage is necessary, a cellulose material is most desirable. On the other hand, if mat shrinkage can be eliminated, a plastic or metal mat in the proper cost range would be most suitable. Accordingly, work was undertaken with both of these concepts in view although the possibility of employing other materials was not eliminated.

Experiments were begun using aluminum as a substitute for the paper mat. Impressions were made on varying thicknesses of foil using cork blankets as in normal paper mat pressing. However, when the thickness of the aluminum sheet was approximately 0.08 inch, the blanket was removed. This procedure resulted in one side of the aluminum sheet being perfectly flat, requiring no backing, while the other side was impressed.

Samples of aluminum sheet were obtained in thicknesses of 0.064 in., 0.091 in., and 0.250 in. (Reynolds Metals Company No. 250, the softest commercial aluminum sheet). Each

FIG. 10

SECTION OF SANDER SHOWING SCREW ADJUSTMENT

sample was placed directly on the type metal and a thin sheet of steel was placed upon the aluminum sample. Pressures of 3000, 6000, and 9000 psi were used on each sample, but resulting impressions were not deep enough. The type itself deformed at these pressures when it was in contact with the aluminum.

Several aluminum foil laminates were prepared using a polyester resin (16) as the bonding agent because of its excellent adhesion qualities. Samples of 10 and 30 layers were built up and the resin cured by hot-pressing the assembly at a temperature of 250° F for 5 minutes. The impression made by the type was satisfactory when a cork blanket was used during the pressing. However, the resulting laminate was so soft that backing was required. Thicker laminates were pressed hot and cold both with and without the cork blanket. The results of cold pressing were unsatisfactory because the impression was not deep enough since the cold laminate was very stiff and hard. However, with the top press plate heated to 200°F., the type impression was much deeper.

Small samples of lead and aluminum laminates were pressed against the type metal. The laminate consisted of one sheet of aluminum 0.01 in. thick placed upon a sheet of lead 1/16 in. thick and the two sheets bonded with a polyester resin. When two sheets of lead were used, the impression was much deeper than with a single sheet. The matter of choosing a

satisfactory adhesive was a problem in itself, since only a few adhesives adhere to metals and fewer still can withstand the high temperatures of the molten type metal.

Larger lead samples ($1\frac{1}{2}$ in. x 20 in. x $\frac{1}{16}$ in.) were covered with a layer of aluminum 0.01 in. thick and pressed. The pressures ranged from 620 psi to 2340 psi, the latter pressure producing deep impressions.

The possibility of applying a highly viscous plastic to the type, allowing it to harden, and then removing it, was considered. A metal band was fitted around the type metal to form a mold and a resorcinol-resin mixture containing 40 per cent asbestos was poured upon the surface of the type and cured at 200°F. using only a slight pressure. The curing time was approximately 15 minutes (although this time could be greatly reduced using thinner films and higher temperatures).

A small sample of Teflon $\frac{1}{16}$ in. thick was obtained and pressed onto the linotype at a pressure of 1650 psi. The impression was fair when pressed cold and nearly perfect when the top platen of the press was at a temperature of 200°-250°F. This material was easily bent into a curved shape. It did not melt or soften at the temperatures of the molten type metal. The impression retained its depth considerably, even after standing two or three days. The amount of spring back of the type impressions was negligible. Although Teflon has many properties which are desirable in

stereotype mats, its characteristic toughness renders it extremely difficult to re-roll.

The possibility of using a thicker paper mat and pressing it against a hard back was considered. Conventional mat samples in two and three layers were pressed upon the linotype, using a hard back. The samples composed of three layers were found to be the more satisfactory, but the impression was not deep enough. The same procedure was repeated except that the small squares were moistened before pressing. Impressions were satisfactory on both samples, but the three-layer sample was the better of the two. The type metal tended to be flattened slightly using only two layers of the mat.

Wetting the paper mat excessively introduced new and possibly serious problems. First, shrinkage might be excessive and, secondly, the time required for complete drying might also be excessive. The data of Table II were obtained to give some idea as to the moisture content of the mat at certain stages in the process.

D. ALTERATION OF MAT FOR COLOR WORK.

Because of the tedious milling operation in preparing type castings for color work, the possibility of altering the mat appropriately prior to casting was considered. The procedure under consideration was the filling in of those

TABLE II. MOISTURE CONTENTS AND DIMENSIONS OF WETTED
MAT AT VARIOUS STAGES IN THE PROCESS

	PRIOR TO PRESSING				AFTER PRESSING			
	Wt. of Wet Sample (Gms.)	Wt. of Dry Sample (Gms.)	Length (Cm.)	Width (Cm.)	Wt. of Wet Sample (Gms.)	Wt. of Dry Sample (Gms.)	Length (Cm.)	Width (Cm.)
1 wet mat with cork cushion	11.857	10.001	54.00	51.25	10.761	9.290	54.25	51.60
"	12.708	9.637	53.85	50.70	12.382	9.821	54.25	51.45
2 layers of wet mat, no cushion	7.961	6.238	45.05	35.50	7.710	6.380	45.35	35.60
"	8.514	6.839	44.80	35.30	8.095	6.713	44.95	35.45
"	7.793	6.406	44.90	35.40	7.769	6.231	45.15	35.60
2 layers - 1 wet 1 dry - No cush- ion	8.080	6.394	44.70	35.35	7.767	6.374	44.85	35.45
"	8.580	6.825	44.90	35.10	8.118	6.707	45.15	35.30
"	8.072	6.615	44.70	35.15	7.897	6.621	44.90	35.25

TABLE II. MOISTURE CONTENTS AND DIMENSIONS OF WETTED MAT
AT VARIOUS STAGES IN THE PROCESS (CONT'D.)

	AFTER DRYING			
	Wt. of Wet Sample (Gms.)	Wt. of Dry Sample (Gms.)	Length (Cm.)	Width (Cm.)
1 wet mat with cork cushion	9.469	9.339	53.40	50.15
"	9.589	9.467	53.30	50.05
2 layers of wet mat, no cushion	6.279	6.221	44.70	34.90
"	6.734	6.693	44.45	34.80
"	6.320	6.295	44.55	34.70
2 layers - 1 wet 1 dry - No cushion	6.526	6.509	44.30	34.80
"	6.603	6.569	44.55	34.60
"	6.452	6.423	44.45	34.55

portions of the mat not to be used for a given color. During the casting, only those portions to be used for the given color would appear in relief. With this proposed procedure, it might be possible merely to paint the filler on those parts of the mat not to be used for a given color, thereby eliminating much of the close milling work.

Sodium silicate was the first material used in the filling in procedure. However, not only was the curing time too long, but it pulverized when molten metal was poured upon it.

Next, a resorcinol resin mixture was filled with aluminum powder and applied to the mat. All samples cracked when subjected to molten type metal, even to the extent of causing particles of metal to be thrown from the resin, especially when the aluminum powder content was high.

DISCUSSION OF RESULTS

A. RESINS FOR MATRIX BACKING.

The results of the first plant tests using pre-cured resin sheets and pressing them directly onto the mat as the latter was being molded were not too encouraging from several standpoints. (1) The high temperature of the Sta-hi dryers caused the resins to blister under the wrapping paper. (2) The metal casting showed that a poor impression resulted. Small bubbles or blisters on the surface of the casting indicated that all the moisture present in the paper was not expelled when dried. (3) Fine lines or cold spots on the casting indicated that the heat of the metal was not absorbed quickly enough because of the insulating properties of the resin backing. (4) The resin warped so considerably during the curing operation that the resulting metal casting was badly deformed and could not be used to print.

Mats with resin-sprayed backing did not fare much better in plant tests. All samples showed insufficient backing. Aside from this fact, however, it was noted that the mats containing the least amount of resin produced the best mold. Bubbles and lines on the mold showed that, as the amount of resin backing increased, the amount of moisture in the mat and the resistance to the transfer of heat also increased. The presence of moisture in the more heavily-backed mats can be explained by the fact that water was used as a solvent, and the mat absorbed much of it. Resistance to heat transfer is due

to the excellent insulating properties of the resin, the thicker coating of resin being the better insulator. The question of heat transfer during this casting procedure is one of great importance since the best crystalline structure in the metal takes place when it is cooled rapidly.

As shown in Table III, the percentage loss of resin sprayed upon the mat varied over a wide range (50 to 85 per cent). The amount of resin actually deposited upon the mat depended, to a large extent, upon the manner in which it was applied since more resin will be lost as the gun is moved further from the mat. This great loss can also be attributed to evaporation of the solvent since it is dispersed into the air in finely divided particles.

B. POROUS SHEET BACKING FOR MATRIX.

The graph of moisture content vs. drying time (Fig. 11) gave a good comparison of the drying times of the mats backed with a solid backing and that with no backing. The significant item observed was with the backing. The moisture content was higher, but the additional moisture was lost so that the total drying time under vacuum should not be excessively increased.

Large pressed portions of the mat that required sanding tended to warp when dried or exposed to atmospheric conditions for a considerable length of time. The Sta-hi

TABLE III. RESIN LOSSES BY SPRAYING

Mat No.	Wt. resin sprayed(gms.)	Wt. resin on mat (gms.)	Wt. resin lost (gms.)	% Loss
1	49.4	23.0	26.4	53.5
2	45.5	19.0	26.5	58.8
3	70.5	34.0	36.5	51.7
4	71.5	19.0	52.5	73.5
5	109.0	21.0	88.0	80.5
6	95.5	32.0	63.5	66.5
7	92.0	24.5	67.5	73.3
8	109.0	38.0	71.0	65.2
9	129.0	32.0	97.0	75.2
10	127.0	39.0	88.0	69.2
11	95.0	41.0	54.0	56.8
12	103.0	23.0	80.0	77.7
13	106.0	26.0	80.0	75.3
14	121.0	36.0	85.0	70.3
15	235.0	77.0	158.0	76.3
16	175.0	40.0	135.0	77.0
17	152.0	42.0	110.0	72.3
18	99.0	18.0	81.0	81.8
19	61.0	9.0	52.0	85.3

FIG. 11 MAT DRYING CURVES

driers at the Courier-Times plant increased this effect since the vacuum pulled all large, unsupported portions to the surface of the drier. When placed in the sanding machine, some portions requiring sanding do not get sanded while the backing is removed from some portions requiring it.

C. NEW MAT MATERIALS.

The data and results of the moisture determination experiments (Table IV) indicate surprising uniformity in the overall shrinkage of the mat during drying with considerable variation in initial moisture contents. Initial moisture contents ranged from 20 to 30 per cent in the wetted mats and decreased to a moisture content of from 0.3 to 1.4 per cent after drying. The maximum shrinkage that occurred in the length was 1.75% while the maximum in the width was 2.81 per cent. The results show the possibilities of additional mat moistening without undesirable shrinkage variations. Accordingly, it was felt that the use of a glue in water solution would not seriously influence the overall shrinkage of the mat.

TABLE IV. MOISTURE VARIATION AND SHRINKAGE
OF WETTED MAT DURING PROCESSING

	Per Cent Moisture Before Pressing*	Per Cent Moisture After Pressing*	Per Cent Moisture After Drying*	Per Cent Shrinkage † Length	Width
1 wet mat with cork blanket	18.55	15.83	1.392	1.57	2.81
"	31.87	26.08	1.289	1.75	2.72
2 layers of wet mat no blanket	27.62	20.85	0.9323	1.433	1.966
"	24.49	20.59	0.6125	1.11	1.83
"	21.65	24.68	0.397	1.32	2.53
2 layers 1 wet, 1 dry, no blanket	26.37	21.85	0.261	1.23	1.83
"	25.71	21.04	0.517	1.33	1.98
"	22.03	19.27	0.451	1.00	1.965

* Dry Basis

† Based on Dimensions After Pressing

SUMMARY AND CONCLUSIONS

The problem of developing suitable materials and techniques for the elimination of hand backing of mats was undertaken. A thermosetting resin, namely, resorcinol-formaldehyde, was selected for investigation and was found to have satisfactory properties when admixed with 15 to 25 per cent short fiber asbestos and cured for 5 minutes at 100°C.

A backing procedure first thought to be successful consisted of coating the entire back of the dried mat with the resin mixture and curing in a semi-cylindrical shape.

The use of infra-red heat in curing the resin backing proved to be no better than hot air heating without pressure on the resin. In fact, blistering occurred more readily when using infra-red than when using hot air heating.

A semi-cylindrical drier was constructed to permit observations of curing times and results with full size mats. The curing times for mats with only a resin backing were approximately ten minutes at temperatures just below that at which blistering of the resin occurred. Since this curing time was considered excessive, experiments to reduce the time led to the development of a technique whereby the resin was first applied to a piece of Kraft paper the size of the mat which in turn was applied to the mat and cured in approximately five minutes.

A convenient method of applying resin to the mat consisted of, first, diluting it with a suitable solvent, and then spraying it upon the mat by means of an ordinary paint

spray gun. Complete cures, using spray methods, were not effected as quickly as when other methods were employed, and the resulting backing was not stiff enough to resist the pressure of the type metal. Another disadvantage this method has is that there is an appreciable amount of loss.

In order to back large areas of the mat, a thin resin layer was sprayed on the mat and different materials were placed upon the wet resin. These materials included blotting paper, sawdust, glass wool, and cotton linters. Of these materials blotting paper was found most satisfactory. Sodium silicate was used to glue the blotting paper to the mat. A mechanical sanding machine was built to remove blotting paper from the high spots on the back of the mat leaving a perfectly backed mat. The following procedure for backing the mats seemed most satisfactory:

- (1) Spraying glue upon backing material.
- (2) Pressing the backing material (such as blotting paper) upon the mat as the mat is being molded by the type.
- (3) Allowing glue to harden.
- (4) Sanding blotting paper off high spots in the mat.
- (5) Final drying in Sta-hi driers.

It was found that aluminum alone could not be used for mats because of its hardness. However, there is a possibility of laminating it using a bonding agent which tends to flow under heat or pressure or both. This type of mat does

not shrink.

Several layers of the paper mat, which have been moistened adequately, produce a deep, clear impression and the mat need not be backed. However, three thicknesses of the conventional type mat or one mat three times as thick as the ones presently used might be employed although lesser thicknesses might be possible with additional adjustments of moisture contents and pressure wetting the mat before pressing results in a perfect impression regardless of whether a cork cushion is used or a steel plate.

The technique of pouring a resin upon the surface of the metal, curing it, and removing it has not progressed far enough to determine conclusively the feasibility of its use. Resorcinol does not show much promise since it flows readily when heat is first applied.

Lead-aluminum laminates showed promise as a matrix material where shrinkage was not necessary. However, a satisfactory bonding medium for the two metals has not been found.

Teflon showed promise because of its excellent heat resistant properties. However, in order for its use to be economical, it must be capable of being re-rolled and used repeatedly. Since Teflon is extremely tough, it is doubtful that re-rolling can be accomplished satisfactorily.

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APPENDIX

GLOSSARY

1. **BLISTERING-** Formation of bubbles in the surface of the resin or paper mat.
2. **CHASE FRAME-** A support around the printing area at the level of type. Frames not level with the printing surfaces of the type are sources of printing failures in stereotyping.
3. **HALF-TONES-** Cut made from a photograph by photographing through a screen to separate the masses of light and shade, to produce a printing surface and depth by etching with acid; an engraving.
4. **MASTIC-** A pasty cement used as a binder for layers of paper.
5. **OPEN-WORK-** Large areas requiring backing.
6. **PLATEN-** Plates of metal used as pressing surfaces in molding machine.
7. **SPRING BACK-** Tendency of mat to return to normal position after being impressed.
8. **STEREOTYPE-** A metal plate representing the exact facsimile of the original, made by casting.
9. **TEGO GLUE-** Brand name for a phenol-formaldehyde resin, applied to thin sheets of paper, and partially cured. Used in laminating plywood.

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