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THE SILK SCREEN PRINTING PROCESS





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THE SILK SCREEN PRINTING PROCESS

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AND

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Second Edition NINTH IMPRESSION

McGRAW-HILL BOOK COMPANY, Inc. NEW YORK AND LONDON 1941



THE SILK SCREEN PRINTING PROCESS

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This book is respectfully dedicated to

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A. I. BARRON

for his inspiration and guidance



PREFACE TO THE SECOND EDITION

It has been very gratifying to learn that our book "The Silk Screen Printing Process" has gone through three printings in less than three years. Instead of using a fourth printing of the same material, we have thought it best to bring out a new edition. In this enlarged edition, the body of the original text has not been altered in any way, since the information contained there is both basic and essential. This work has been expanded to include chapters on estimating, shop management, and recent technical developments.

In the first edition the authors avoided the use of trade names to identify silk screen materials sold in the competitive market. Our efforts to be impartial in this matter have caused many readers to write letters requesting specific trade names and addresses of dealers. In the present edition the authors have been less reluctant to mention names, especially when they serve to distinguish a specific product from similar products on the market. Since it is impractical to list the names and addresses of silk screen supply dealers in all localities, the reader is referred to the *Signs of the Times*, the national trade magazine which carries silk screen advertisements.

The authors wish to renew their thanks to their many friends for their spendid cooperation.

J. I. BIEGELEISEN, E. J. BUSENBARK.

New York, N. Y., January, 1941.

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PREFACE TO THE FIRST EDITION

The recent developments in the silk screen process and the rapid extension of its application to new materials and new uses have far surpassed the limited amount of available literature on the subject. Formerly, silk screen information was disseminated chiefly among sign-shop operators. Since it was taken for granted that they already had a fair working knowledge of the process, writers neglected to explain many essential technical details.

In undertaking to write a textbook that would include all the recent technical advances in the process, the authors had a twofold objective. They have tried to make this book serve not only as a reliable source of information for commercial users, but also as a step-by-step manual for arts and crafts students, amateur and professional artists, and hobbyists. In other words, they feel that this book should be useful whether one wishes to use the process as a vocation or as an avocation.

Many illustrations of silk-screened specimens have been included to supplement the text. Photographic reproductions cannot fully convey the beauty of full-sized colored subjects, but they should help give the reader a better visual conception of the potentialities of the process than he could' glean from the written word alone.

The authors have tried to make this book thorough. Though striving for completeness, they have tried to resist the temptation to include all the stunts or shop tricks that have ever been used. If a method has been found from experience to be impractical, it has been omitted. In all cases they have stressed that which definitely *will* work rather than that which *might* work.

For their kind cooperation in granting the use of the specimens here reproduced, the authors wish to express their appreciation to: Mr. A. I. Barron of the Paint Print Process, Inc.; Mr. Michael M. Engel, director of Artists Relations Bureau of M. Grumbacher Company; Mr. George E. Garcia of the Sign and Display Guild; Mr. Martin Gruber and Mr. William Boraczek of the Gruber Display Company; Mr. Benjamin Labov of the Union Ink Company; Mr. Sam Lubliner of the Modern Mirror Novelty Company; Mr. H. S. Morgan, art director of the American Can Company; Mr. D. L. Nelke of the Nelke Sign Manufacturing Company; Mr. Joseph Ulano of the Nufilm Company; Mr. Duke Wellington and Mr. Victor Singer of the American Display Company; Mr. Grant Warren of Warren Displays; Mr. Morris Glicksman, Mrs. Louise Mazur; Mr. Joseph Rainman; Miss Bessie Schaer.

In acknowledgment of their friendly encouragement and helpful suggestions, the authors wish also to thank: Mr. Lawrence E. Blair of the University of Wisconsin; Mr. George K. Gombarts, principal of The School of Industrial Art, New York; Dr. Forrest Grant, director of art of the New York City Schools; Mr. Francis Mahoney, supervisor of vocational classes of the New York City Board of Education; Dr. D. J. McDonald of the New York State Department of Vocational and Extension Education; Mr. G. G. Weaver, supervisor of industrial teacher-training of the New York State Department of Education.

> J. I. BIEGELEISEN, E. J. BUSENBARK.

New York, N. Y., December, 1937.

INTRODUCTORY NOTES

In the course of many contacts and experiences in the field of industrial art, I found the silk screen process in operation in sign shops throughout the city. The early process seemed at that time to be intricate and unsuited to school purposes. Today, the vastly improved stencil printing process, whose colorful prints seem definitely worthwhile, makes silk screen fit into the modern educational pattern.

With the improvement and development of the process, a class in silk screen printing was opened with a group of adults at the New York Evening School of Industrial Art. Gratified by the success of this undertaking, I afterward had it introduced as part of the commercial art course in the School of Industrial Art. I note with satisfaction that process printing is being gradually incorporated in the courses of study of a number of New York City schools, as well as in schools throughout the country, thus confirming my own belief as to its suitability and usefulness.

Screen printing is taught not only as a craft, but also as a vital phase of commercial art. Its vocational aspects have already been realized, and students with artistic leanings are being trained to take their places in this rapidly-growing and profitable industrial field. Indeed, silk screen printing has found a permanent place in the school curriculum.

The book, THE SILK SCREEN PRINTING PROCESS should prove a source of inspiration to those wishing to learn or teach the subject, as well as to those already engaged in this type of work. It is a comprehensive, dignified, and understandable text, based upon much experience, and it should have a definite place in every commercial art studio and library.

GEORGE K. GOMBARTS,

Principal, School of Industrial Art, New York City.

It has been a privilege to read the manuscript of this complete and understandable treatise.

I have found that manufacturers and commercial artists are rapidly adapting stenciling to graphic-art reproduction, and I feel confident in predicting an ever-widening use of the silk screen process in the commercial field.

By means of this process, advertisers are able to handle certain types of work which, because of technical limitations or manufacturing costs, heretofore have been more or less prohibitive.

In spite of the extensive use of this process, both in this country and abroad, it is surprising how meager has been any reliable information on the process as such, and it would seem to me that this book bridges this gap and is most timely.

H. S. MORGAN,

Art Director, American Can Company, Merchandising Specialties Division.

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THE SILK SCREEN PRINTING PROCESS

CHAPTER I

INTRODUCTION

GENERAL DESCRIPTION OF THE PROCESS

Silk screen stencil printing is essentially a process in which the stencil bearing the design to be reproduced is permanently affixed to a screen or ground consisting of silk, organdy, or metal cloth. Paints or other printing mediums are forced through the stencil and deposited on the printing surface, thus forming a facsimile of the original design. The method is known as the silk screen process because, originally, silk was exclusively employed for the screen.

The vital difference between printing designs with the old familiar shipping-case type of stencil and printing from modern screen stencils is that in the latter method the stencil is an integral part of the screen. Permanently combining the stencil with the fine mesh of the silk makes it unnecessary to employ bridges or ties to hold in place the centers or island parts of the stencil, such as occur in the letters D and O. This simple elimination of the bridges or ties completely revolutionized stencil printing by vastly improving the appearance of the prints, by making quantity production practicable, and by extending the application of the process to an unlimited variety of subjects.

The origin of the process has, by some writers, been attributed to the ancient Chinese. Others credit its development to the Egyptians, but definite evidence cannot be found to substantiate either of these suppositions. The nearest early prototype of the present method, of which we have positive knowledge, is the old Japanese method of stencil making.

In this process the stencils were cut in duplicate from very thin paper. A layer of hair was laid in crisscross fashion



FIG. 1.—Old type of stencil with ties to hold the centers in place.

between the two stencils, and the whole permanently lacquered together. The hair held the centers of the design in place, thus, in part, performing the function which is today filled by the silk screen.



FIG. 2.—Modern knife-cut film stencil. This stencil was used in printing the display reproduced on page 79.

There is almost as much conflicting opinion about the first modern use of the screen method as there is about its use in past centuries. It is believed by some that the process originated in France; others hold that it was first used in Germany about 1870; and still others contend that

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it originated in England some time prior to 1900. It is known, however, that a patent was granted in England in 1907 to Samuel Simon of Manchester, covering the process as it exists today except that Simon used a brush instead of a squeegee to force the paint through the silk.

In America, silk screen stencils have been used for printing designs in one color on felt banners, pennants, arm bands, etc., for the past 40 years. In about 1914 or 1915 a multi-color process was developed by a commercial artist named John Pilsworth of San Francisco, who improved the stencil process then in use for printing banners and pennants by permanently attaching the stencil to a piece of silk bolting cloth. This method was patented by Owens, and later became known as the Selectasine or single-screen method.

From California the use of the new method spread eastward. At first it was looked upon as a tedious process, requiring too much painstaking effort for practical commercial work. During the World War, when general advertising received a great impetus, it was employed with great success by sign painters and makers of cloth and felt banners. At that time the actual method of reproduction was guarded as a trade secret, much of the work being sold as original, hand-painted products. The "secret" soon became known however, and, during the past 15 years, an industry has grown up in which a large number of silk screen craftsmen are employed.

This rapid development has unquestionably been due to the fact that the screen method can be employed on a greater variety of surfaces, and for a greater range of uses, than any other printing method ever developed. It works equally well on textiles, paper, cardboard, corrugated board, felt, glass, wood, or metal, and with dyes, tempera paints, oil paints, enamels, or lacquers.

Some of the results obtainable by this process cannot be as satisfactorily produced by any other method. For one thing, the prints are more brilliant than those produced by

other methods and more closely resemble the original hand-painted work, because the stencil assures an actual layer of pigment being deposited on the printing surface. Again, the natural opacity and covering property of paint make it possible to print a light color over a darker one. The usual printing methods, employing ink instead of paints, have never been able to do this successfully. Furthermore, large banners and posters, 20 feet or more in length, may be printed in one piece, whereas, by lithographic or other methods, they have to be printed in a number of small sheets or sections, and then assembled. Standard types of printing presses are designed to handle paper of certain prescribed thicknesses, so that, if a reproduction is to appear on heavy cardboard, it is usually necessary to print it on thin paper and mount the print on the cardboard afterward, while another sheet of thin paper must be mounted on the other side of the cardboard to overcome warpage. These operations are unnecessary in screen printing, because the processing equipment may be easily adjusted to print on material of any thickness, the cost of mounting and countermounting thus being eliminated.

One very important advantage of the screen process is that the installation and maintenance of the necessary equipment require but a fraction of the capital necessary for installing the complicated machinery used in printing plants of the lithographic or letterpress type. This economy makes it possible for the small advertiser or manufacturer to secure limited quantities of printed matter at reasonable cost; whereas, were it necessary for him to have his work done by other methods, the price in many cases would be prohibitive.

It is not to be expected that screen printing will supplant other processes, because, like all other methods, it has its limitations; but it should be considered as a distinct and practical graphic art process. In fact, one may often see work in which lithography and screen printing are successfully combined. Being a hand method, it is most practicable for work in which the quantities do not exceed 10,000, because as the runs exceed this quantity, other methods become relatively cheaper. Furthermore, the screen process is not so suitable for subjects containing subtle shading or blending of color as for simple, flat, poster work.

Inasmuch as the process originated in the advertising field, it naturally came into extensive use in that field before it was applied to manufactured products. Screen printing was next introduced into the textile industry by batik dyers, who learned that instead of having to wax designs on cloth by hand, thus making an original design on each piece of material, their designs could be repeated mechanically on a quantity basis by applying dyes to the cloth by means of a screen stencil. Adoption of the process by the general textile industry was the next logical step.

Use of the process for printing decorative designs, lettering, trade-marks, and instructions on manufactured articles, came more slowly; but, once started, it spread rapidly, and within the past few years has increased with amazing speed. Today the process is used for applying designs to such diverse objects as chests, tables, beds, book ends, and other household articles, including nursery furniture and toys; for printing on machinery, storage batteries, corrugated shipping containers, vacuum-cleaner bags, automobile-tire covers, lampshades, greeting cards, pinball games, cloth novelties, and bridge-table covers. It is used in printing wallpaper and decorative wall panels; for applying colorful designs to oilcloth and waterproof paper for bathrooms, etc. By means of it, type matter and decorations are applied to milk, drug, and cosmetic bottles and containers, as well as to household glassware and It is used in making decalcomanias of designs to ceramics. be placed on show windows, on the sides of trucks, busses, streetcars, and machinery. Very recently new methods have been developed for etching designs on glass signs, display cases, table glassware, chromium, and other highly

finished modern metals. Scarcely a month passes in which the process is not applied to some new product, or in some new manner; yet the application of screen printing to industry is still in its infancy.

With the rapid development of the process in industry, a similar pace has been maintained in the field of advertising, wherein new materials and new treatments are being constantly employed.

BASIC PRINCIPLES OF THE PROCESS

The screen-printing process is made possible by the fact that, when paint is poured on a meshed fabric, the paint will seep through the mesh. However, in order to make this the basis of a practical printing process, it is necessary that the paint be made to penetrate the mesh quickly and evenly; and this is accomplished in the screen process by pushing the paint across the surface of the silk with a rubber blade, or squeegee, which instantly forces the paint through the open parts of the fabric.

Because of its tensile strength, durability, and perfect weave, imported silk bolting cloth, such as is used by flour millers, is the fabric most generally employed for the screen or ground.

Another step necessary to make the process a practical one is to stretch the silk taut on a wooden frame which may be fastened by hinges to a rigid base. Fastening the frame on hinges makes it possible to move the frame up and down, without any side sway. This arrangement makes it more convenient to raise and lower the frame for the insertion and removal of the printing material and also makes the frame always come to rest on the base in exactly the same position.

If a part of the silk screen is now masked or blocked out with paper, lacquer, shellac, glue, or other stenciling material, and paint is squeegeed over the whole surface of the silk, it will be found that the paint flows through the open area but does not penetrate where the silk has been

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thus blocked out. Since it is possible to make the masking medium conform to any arbitrary pattern, the blocking-out process may be used to form a stencil of any shape or pattern desired.

For instance, a simple flower shape may be cut out of paper and pasted on the underside of the silk screen; thus the mesh of the silk is left open except where this paper stencil is applied. Or, we may reverse the process: instead of using the silhouette of the flower itself, we may use the paper from which it was cut. In the latter case, all of the screen will be sealed except the area which corresponds to the shape of the flower.

In the first example, if red paint is squeegeed through the screen on to a piece of white cardboard, the paint will be deposited on the entire surface of the cardboard except where the paper mask has prevented penetration, the result being a white flower on a red background. If we use the second stencil, the white cardboard will remain the background with the flower printed in red upon it.

This is a brief and incomplete description of the silk screen process. Numerous kinds of stencils and printing mediums may be used for printing on an infinite variety of surfaces. In the following pages, each step and detail of the complete process will be described in simple language, so that the reader may know how and when any of the various stenciling methods may be employed to the greatest advantage.

USES IN THE FINE AND APPLIED ARTS

Applicability of the screen process to the fine and applied arts has been recognized rather belatedly. Vocational schools did not begin to include the subject as a special course in their curricula until very recently.

The versatility of this process in classroom work assures its permanent inclusion among school arts and crafts, but the subject is still so new that its possibilities have not yet been fully demonstrated.



Fig. 3.-Example of student work.

Besides its usefulness in the decoration of textiles, furniture, and all kinds of glass, wood, and metal novelties for use in the home, the economy and simplicity of the process make it ideal for printing greeting cards, magazine covers, announcements, and posters for school activities.

The equipment used may be rather elaborate, or it may be just as simple as one wishes to make it. For most amateurs and students, a printing frame, a squeegee or two, and a solidly built utility table are the only implements required.

Most of the original drawings for such designs are made with water colors or tempera paint. Suggestions for the preparation of drawings of this nature for screen reproduction will be found in the chapter on commercial drawings. However, there are many ways of preparing drawings of a noncommercial nature which will be especially useful to both students and artists. For example, if one wishes to make a small number of greeting cards or announcements in one color, an economical method is to prepare a carefully drawn sketch of the design in ink, tempera, or pencil, and then make a stencil from it with which to print the required number of copies.

The novelty of the prints may be enhanced by printing them on crepe, blotting, or Manila paper, or on various kinds of gaily colored stock. If it is desired to brighten prints which have been made on plain paper, this may be done by tinting the prints with water colors. Other colors may be added to one-color prints by cutting parchment paper or celluloid stencils for the extra colors, leaving the stencils open in the spots where the various colors are to appear. After the stencils are placed in their proper positions over the print, either transparent water colors or tempera colors may be applied with a brush. However, for this kind of work, a more efficient way is to plan the whole job for screen printing from the beginning. For a small quantity of cards in which simple spots of color are to be added to a key color, paper stencils will fully serve the

purpose, and may be cut and applied to the screen in a few minutes.

If one wishes to do so, one may make a colored tint block to extend beyond the margins of the design. To do this it is merely necessary to make a separate stencil for the tint and print it first, after which the design may be printed over it. Carrying the same idea a step farther, one may prepare the original drawing on gray or light-colored board. If white is to appear in the design, it is painted in with a The black is then brushed in with ink or tempera brush. Of course, any other colors may be used instead of color. those specified here. This is a very fast and simple method, by which some striking effects may be obtained. The reproduction of such a drawing may be planned in either of two ways: the prints may be made on white paper, in which case the black and the gray must be printed; or the prints may be made on gray paper, using stencils for the white and black.

A feature of one type of screen printing which should be of particular interest to professional artists is that, for many types of work, they may, if they wish, avoid making a finished drawing on paper. In order to do this one must first prepare a rough pencil draft of the proposed design and place it under the screen, after which the finished design is painted directly on the silk with liquid tusche, or drawn with grease pencil or tusche crayon, as described in the chapter on resist stencils. This approach is particularly desirable when the artist wishes to obtain freely drawn, spontaneous effects. It is also a very quick, direct method for making contour or outline drawings.

A recent innovation in screen printing is the making of prints which, while very closely resembling wood-block prints, have a distinct charm and quality of their own. The artistic character of the prints produced in this way warrants consideration of the process by artists who make prints for exhibition.
Those who have had experience in making wood-block and linoleum prints have recognized many limitations and objections to these mediums. A comparison of them with screen printing methods easily shows the superiority of the latter.

In making wood-block prints in several colors, the methods employed for registering one color over another are crude and entail considerable guesswork. The making of really good prints requires the use of some kind of printing press. It is also much more difficult to make black lines on white than it is to make white lines on black.

Inasmuch as the design to be cut must be traced on the block in reverse, any lettering which is included will read backward on the block. To cut out the lettering accurately in this mirror-like position is somewhat difficult.

It is also difficult, and extremely tedious, to cut the block so as to print black crosshatched lines on a white ground. If very thin lines appear in isolated positions on linoleum cuts, there is danger of the lines breaking down when pressure is applied to make the print. Designs which include large white areas are likely to print badly unless there is a border around the design, to hold up the paper and keep it from being forced into the tooled areas and getting smudged.

The cutting of either wood or linoleum is a slow, laborious process: the rigid, unyielding nature of both tools and materials makes it impossible for the average worker in arts and crafts to do more than gouge out broad, simple masses. Delicate black lines and other details on white cannot be successfully achieved except by expert workers. These natural barriers to free expression seriously limit the scope of block printing, both as to the subject matter to which it is adaptable and as to the techniques or treatments which may be employed.

The screen process frees the artist from these hindrances and enables him to change at will from broad, posterlike effects to the reproduction of thin pen lines. There is no necessity for the artist to put a border on his drawing unless he feels that doing so will improve its appearance. White lines on black, or black lines on white, may be made with equal ease. Crosshatched lines do not offer any



FIG. 4.

Figs. 4 and 5.—In these examples the same stencil was used for printing with black on white, and with white on black.

serious problem, nor is there any difficulty in the registration of colors.

If he wishes to do so, the screen printer may make prints which so closely resemble wood-block prints that only an expert can distinguish the difference. It seems unlikely, however, that craftsmen will continue to impose the limitations of woodcut making on their work, once they become familiar with the methods of screen printing and realize the increased range and freedom of expression they provide.

Although an experienced artist may safely make minor changes in the sketch when preparing the stencil, a beginner should take care that his composition, drawing, and



FIG. 5.

spotting of black-and-white masses appear on the original exactly as they are to appear in the reproduction. This is especially necessary if the work is to be in more than one color as success will depend largely upon the quality of the original.

Surprisingly fine detail can be printed by the screen process, but it is advisable that the beginner avoid fussiness

and overelaboration of detail. Simplicity is an essential in this as in any other form of art.

For work of a flat, posterlike quality, or when clean, sharp lines are required, film stencils will be found most satis-



FIG. 6.—Portrait drawing in woodcut style, printed with a tusche resist stencil.

factory. When it is desired to produce broken tones, or lines with soft, irregular edges it is best to use resist stencils. These types of stencils will be discussed in later chapters.

The accompanying illustrations suggest some of the possibilities of the process with such subjects as landscapes, street scenes, and figures.

The illustration, Fig. 7, on page 15, was reproduced by photoengraved plates from a screen print in black and white, the print having been made from a stencil which was prepared from an original wash-out type of drawing in woodcut style.

Obviously, any design in black and white or color which does not contain blended or shaded tones could be easily screened in the same way. In this particular case, the



FIG. 7.-Landscape drawing in woodcut style, printed with a tusche resist stencil.

artist employed the wash-out method in making his original drawing in order to illustrate how nearly screen prints may be made to simulate block prints.

Because many novel effects may be produced by the wash-out method, we shall describe the process briefly. First, the picture is sketched in lightly with pencil on kidfinish bristol or No. 80 illustration board. Then, to a small quantity of poster white (tempera color) just enough blue should be added to make the paint contrast with the paper. The paint should be heavy, and contain plenty of glue. Wherever white is to appear in the final drawing, the paint must be applied with a red sable water-color brush, all parts which are to appear as black being left untouched. It will be observed that this procedure is somewhat the same as that followed in cutting a wood block. The white



FIG. 8.—Decorative panel, printed with a tusche resist stencil.

areas of a wood block are chiseled out with the gouging tool. In the wash-out method, they are cut in with paint and brush.

In order to avoid monotony in the appearance of the drawing, both pointed and square-ended brushes may be



FIG. 9.—Simple but effective cover design printed with film stencils.

used, as judgment may dictate. Numbers 3 and 5 pointed brushes and Nos. 1, 3, and 5 square-ended rigger brushes are convenient sizes.



FIG. 10.-Effective posterized street scene reproduced with film stencils.

The tempera should be applied to the paper thickly with a fully charged brush, so that the ink to be brushed over it later will not seep through the tempera to the paper. Little spots, lines, and ragged edges may purposely be left uncovered. It is the discriminating use of such "accidentals" which gives the finished drawing the rugged quality which is characteristic of woodcut prints.

After the parts which are not to appear as black in the picture have been painted in with tempera, waterproof ink is brushed over the entire surface of the paper. While the ink is being applied, the paper should be held in a slanting position so that the ink will flow downward and not form pools. The paper should then be placed under running water until the paint is all washed off. In all parts where the ink is applied directly on the paper, it will not wash off in this operation, but will cling to the paper to form the desired picture.

If an air brush is available, the ink may be sprayed instead of brushed on. When ink is sprayed, it is emitted in such fine particles that, even though the tempera paint be applied very thin, there is no danger of the ink soaking through to the paper where it is not wanted.

Upon completion of the original drawing, the next step is to prepare a resist stencil before printing the desired number of impressions. Instructions for preparing the stencil will be found in the section covering that subject.

The wash-out method of making drawings is especially useful when it is desired to produce woodcut effects involving much fine detail. However, for subjects which consist only of broad, simple masses, it is much easier to sketch the design lightly with a white pencil on hard black cover paper and paint in the design later with white tempera paint. White line drawings on black paper also produce many novel effects which are not readily obtainable by other methods. After preparing the stencil from an outline drawing, the print may be made either by printing with white paint on black paper or by using black paint on white paper.

The uses here suggest but a few of the many ways in which screen printing may be employed in the fine and applied arts.

CHAPTER II

EQUIPMENT

As has been stated previously, screen printing equipment may be as simple or as elaborate as one wishes to make it. For students and others who wish to employ the process as an avocation, the only equipment required, in addition to the art materials used in preparing the original drawing, includes the following: A small portable printing outfit con-



FIG. 11.—Portable screen and base for amateur use.

sisting of a silk-covered frame which is attached by means of hinges to a wooden base; a squeegee or two; a small quantity of film and tusche for making stencils; paint; cardboard or paper, for making the prints; turpentine, kerosene, alcohol, and lacquer thinner, for removing the stencils and cleaning the screen after the work is finished. A complete outfit for amateur work need not cost more than \$5.00.

For commercial work, the equipment needed by any one shop will depend on the types and volume of work to be done. Some of the larger firms have complete equipment for embossing, die-cutting, and finishing cutout window and counter displays. Some shops install complete photographic equipment, including dark room, facilities for making photo stencils, and making color separation for color-process work.

Makers of metal specialties such as display stands, racks, and cabinets may require a spraying booth, air compressor. exhaust fan, and spray gun for spraying paints or lacquers on the metal. Their equipment may also include facilities for stamping, cutting, and embossing metal as well as ovens for baking vitreous enamel or paint.

If a great deal of work is to be done on glass, the equipment may include facilities for silvering and etching glass, as well as for polishing, grinding and boring. Firms which are engaged in printing designs and advertising matter on bottles, drinking glasses, etc., find it necessary to install special equipment for applying the enamel and baking it on the glass.

Some large plants contain machinery for paint grinding, and power-driven printing tables.

Most screen-printing shops handle all kinds of work rather than specialize in one type or class, and, consequently, their equipment must be sufficiently efficient and flexible to handle readily practically any ordinary kind of job. They must be able to turn quickly from printing on paper, cardboard, or container board to printing on cloth, felt, wood, metal, or glass. The equipment to be described here will be such as may be found in a well-equipped shop of this type. However, if one plans to open a commercial shop, it is best to begin with a mere nucleus of the most essential things, then add to them as the growth of the business justifies it, rather than burden oneself at the outset with an overelaborate plant.

PRINTING FRAMES

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A small printing frame may be constructed by nailing together four pieces of 1- by 2-inch lumber as shown in Fig. 12, or by mitering the corners as shown in Fig. 13. Large frames should be made of heavier material, say $1\frac{1}{2}$ by 2 inches. The wood selected may be spruce, cypress, basswood, or white pine, provided that it is kilndried and free from knots, warpage, and other imperfections.

The frame must be perfectly rigid in construction because any movement or play in it will destroy the precision of registration. A carpenter's plane should be used to bevel the outside edge of the frame on the side over which the silk is to be stretched. This will eliminate the sharp edge which would otherwise cut the silk when it is stretched on the frame. It will also make it easier to stretch the silk. Before being used, the frame should also be gone over with



FIG. 13.—Mitered frame.

fine sandpaper to remove any roughness, and given a protective coat of shellac or lacquer. For extra rigidity, the frame may be reinforced with angle irons screwed to the top of the frame at each corner.

If the frame is made by a skilled carpenter or cabinetmaker, the corners will probably be tongue-and-groove joints, as shown in Fig. 14, rather than merely nailed together. In this case angle irons would be unnecessary. Ready-made frames may be purchased, which are expertly constructed, well mitered and beveled.

The function of the frame is to act as a support on which to stretch the silk and to serve as a reservoir for paint. There must be enough space at each end of the frame to hold the supply of paint, and the sides

of the frame must be wide enough to permit free movement of the squeegee. The frame must therefore be at least 2 inches wider and 6 inches longer (inside dimensions) than the stencil it is to hold.

For example, if an area 14 by 22 is to be printed, the correct size of the FIG. 14.-Specimen corinside of the frame will be approximately



ner constructions.

16 by 28 inches. Larger frames require a proportionately greater space for the paint supply. The specifications given here are intended as general suggestions, not to be followed rigidly.

Grooved Frames.—Figure 15 shows a frame to which



FIG. 15.—Grooved frame.

the silk is attached without the use of tacks. A groove about $\frac{5}{8}$ inch wide and $\frac{5}{8}$ inch deep is made in the center of the underside of the frame and extending all around. To attach the silk. the frame is laid on the table. grooved side up, and the silk laid over it. Several tacks or staples are then driven

through the edge of the silk into the frame, to hold the silk in place until the strips are inserted. Strips of wood which fit into the grooves are then pressed into place and fastened down with screws about 3 inches apart. After the first side is fastened down, the silk is stretched tight over the frame while the strips are forced into the remaining grooves. By this method the silk is held tight between the grooves and the strips, and yet it can be removed more quickly than if it were fastened down with tacks.

Grooved frames are very popular with some workers, although others have found that strips do not hold the silk firmly enough.

Floating-bar Frames.—After long use, silk is liable to stretch and so make accurate registration difficult. To





FIG. 17.—Full-floating-bar frame.

facilitate tightening it and keeping it taut, types of frames are sometimes used which are known as the single-floatingbar, double-floating-bar, and full-floating-bar frames.

The single-floating-bar consists of a strip of wood of the same thickness as the frame, placed inside the frame crosswise, about 2 inches from one end. The silk is attached to this floating bar instead of to the end of the frame. Long screw bolts extend from the ends of the floating bar, through holes in the frame, and project beyond the end of the frame about 1 inch. Wing nuts are screwed on the ends of these bolts and when it is desirable to tighten the silk, the nuts are simply screwed tighter on the bolts. The single-bar frame is not wholly satisfactory because it allows the silk to be tightened in one direction only, forcing the cross threads of the silk to curve more or less in the center. The double-floating-bar type of frame is sometimes employed to overcome this objection. The construction of this is similar to that of the single-bar frame, except that the bars extend along one end and one side of the frame instead of along the end only. The full-floating-bar type is characterized by bars extending along all four sides of the frame and really constitutes an adjustable frame within a frame.

In this case the silk, attached to the floating bars all around, is not connected with the outer frame at all.

The Upright Frame.—Upright frames are sometimes used for printing on the vertical surfaces of such objects as machinery, walls, windows, and bulky pieces of furniture. These frames are made just like ordinary printing frames except that a special reservoir must be attached to the bottom of the frame to hold FIG. 18.—Upright frame.

the paint supply. The paint used with upright frames must be much stiffer than that used with ordinary frames.

PRINTING BASE

The frame rests upon a base to which it is attached by hinges. The surface of the base must be absolutely flat, because any unevenness or warping will interfere with perfect printing contact.

The base should extend several inches beyond the edge of the frame on all sides. For example, if the outside dimensions of the frame are 20 by 30 inches, the base should be not less than 24 by 34 inches.

Artists' drawing boards are sometimes used for the base. Five-ply panel board is also used successfully but is not substantial enough for large frames. If a rigid table is available, the base may be dispensed with entirely, as the frame may be fastened directly to the top of the table. The table should be 34 or 36 inches high. In commercial shops, the measurements of the average table top are about 36 by 50 inches.

Before using a new base it is advisable to give the surface a coat of shellac or lacquer. This will minimize any tendency of the board to warp by absorption of moisture and will also make it easier to clean.

HINGES

Ordinary brass door hinges, or pushpin hinges, should be used to attach the frame to the base. By removing the pins, the operator may detach the frame without unscrewing the hinges.

The hinges are first attached to the frame, being screwed into one of the long sides a few inches from each end. The frame is then placed in proper position and the other sides of the hinges are screwed to the base. When the hinges are properly attached, it should be possible to raise and lower the frame without any side play.

If the equipment includes a number of frames of approximately the same length, the position of the hinges on each should correspond exactly to the position of the hinges on the base. Accordingly, with but one printing table or base, it is possible to use a number of frames of slightly different sizes, if the hinges on all of them fit the master hinges. The changing of frames then becomes a very simple matter.

It should be observed that, in hinges of the pushpin type, the male half of the hinge has three loops or rings, while the female half of the hinge has but two loops, allowing the two parts of the hinge to interlock. When attaching the hinges to the frame it is best to place a female part at one end of the frame and the male part at the other end of the frame. This is done in order that when using one base for several different frames, only one complete hinge

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is required for each frame. If two male parts were used on each base, every frame would require the use of two female parts, and the male part of each hinge would have to be discarded.

If the male half of the hinge is placed near the right end of the frame, this same procedure should be followed in hinging all of the frames, for otherwise it would not be possible to use several frames

interchangeably upon one base.

With continued use, the hinge pins become worn and loose, permitting the frame to wobble slightly. This can easily be overcome by removing the pins and bending them slightly in the middle. This will cause them to bind very tightly when they are driven back into place.



Although frames are sometimes hinged at the ends, it is much better to hinge them at the sides, especially if they are large. When a frame is hinged at one end, the operator, who must work from the opposite end, must bend over and reach to the far end of the frame. This makes the work very tiring.

There is another annoying and time-wasting feature of operating from the end of the frame: after the squeegee is drawn toward the operator, the frame is raised to remove the print; and, as this is done, the paint at the raised end of the frame flows down toward the other end. This tendency of the paint to accumulate at the hinged end makes it necessary to scoop up the paint continuously and transfer it to the other end.

Attaching the hinges to one side of the frame, however, permits the operator to push his squeegee from end to end with a long, easy stroke. He uses his right arm to push the squeegee toward the left, and his left to return it toward the right, making a separate impression with each stroke.

COUNTERBALANCES

During the printing operation it is necessary to raise the frame for the insertion and removal of the material each time an impression is made. Some sort of device is necessary to hold the frame in the raised position while the operator removes the print and inserts another piece under the stencil. Various counterbalancing systems of weights,



FIG. 20.—Simple outfit for commercial work.

springs, ropes, and pulleys have been devised for this purpose, a few of which are illustrated on pages 29 and 30.

A simple arrangement which answers the requirements of most beginners consists of a leg stand attached to one side of the frame, as shown in A, Fig. 20. This is merely a piece of wood, with a hole drilled in one end through which a nail or screw is driven into the side of the frame. The hole should be slightly larger than the nail so that the leg may swing freely and drop down automatically to act as a support whenever the frame is raised.

Another simple arrangement is shown in A, Fig. 24. This consists of a coil spring like those used on ordinary screen

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doors. One end of the spring is attached near the top of an upright post fastened to the side of the printing table, and the other end of the spring is fastened to the



FIG. 22.—Lever weight counterbalance.

end of the frame. The tension is adjusted so that, as soon as pressure on the frame is released, the spring pulls the frame upward away from the base. This arrangement works very satisfactorily in most cases, but the spring may have a slight tendency to pull the frame toward one end. This tendency can be counteracted by attaching another



FIG. 24—Position for squeegeeing.

spring arrangement at the opposite end, so that the pull of one spring may be offset by the other.

When very precise registration is necessary, the frame is lowered and stationary blocks or cleats are placed snugly against the ends of the frame and screwed to the base. These blocks should be rounded off on the side toward the frame. Then, each time the frame is lowered it drops between the blocks with no possible side play. See B, Fig. 20.

The same purpose may be served by an adjustable cleat fastened to the base. When the

frame is lowered, the cleat forces it into correct printing position.

Another way to prevent side play is to bore a hole through a front corner of the frame and about $\frac{3}{4}$ inch into the base. A dowel pin is then driven through the hole in the FIG. 25.-Adjustable cleat frame until it projects about $\frac{1}{2}$ inch.



for close registry.

Then when the frame is lowered, the dowel pin falls into the hole in the base, thus locking the frame in position. A heavy nail may be driven through the frame into the base for this same purpose, but it is not quite so satisfactory because a nail will gradually enlarge the hole by use.

REGISTRY GUIDES

In order to obtain quick and accurate printing, some



FIG. 26.—Registry guides.

means must be employed to place successive pieces of the material to be printed in exactly the proper position under the stencil. No one registration system will serve in all cases, because of the many different kinds of material

which can be printed by the screen method. A system of registration which may be practicable for one job may be wholly inadequate for another. A few of the usual methods employed will be described here. These will serve as suggestions which the operator may use to devise new systems as he needs them.

For printing on paper or cardboard, registration is assured by fastening guides to the printing base as shown in Fig. 26. These guides may be made of wood, cardboard, shellacked cardboard, metal, or celluloid. Guides should be no thicker than the material to be printed; otherwise they will interfere with the contact or cause injury to the silk when the squeegee is passed over the screen. For long runs of printing on cardboard, it is best that metal guides be used, card-board guides only being suitable for very short runs. Linotype slugs of various thicknesses make excellent guides and are obtainable from printing shops.



FIG. 27.-Type of guide sometimes used when printing on thin paper.

The original design must be laid on the base and centered under the screen, so that the guides may be placed and fastened in position. Although the four-guide system is sometimes used, the three-guide method is recommended as being most satisfactory. When a card is centered under the stencil, the long edges of the card should be parallel with the sides of the frame. Two guides may then be placed along the edge of the card toward the operator, as illustrated. If the cards are not to be trimmed later, a left-hand side guide will be found most convenient. If a card is to be die-cut, the side guide should be placed near the lower right corner, instead of the lower left.

Figure 27 shows a simple and accurate guide which is very useful when printing on thin paper. This guide

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consists of a strip of gummed paper which is folded in the middle, one end of the paper being pasted to the base.

Printing on cloth requires an entirely different method of registration, for such material is flexible and subject to stretching. One method of solving this problem involves the use of nails. If a cloth sign of, say, 30 by 40 inches is to be printed in several colors, the cloth is registered under the stencil. Then three or four nails are driven through the edges of the cloth on each side. The heads of the nails are then cut off with wire snips. Each piece of cloth to be printed is then in turn forced down on these nails and, as succeeding colors are run off, the holes in the cloth are fitted



FIG. 28.—Celluloid flap guide.

to the respective nails, thus insuring that each impression will be in proper registration. This method can be used, however, only when the cloth has sufficient margin to permit trimming off the part containing the nail holes after the prints are made.

Accurate registration on cloth may be achieved by temporarily attaching it to cardboard before the printing operation. It may be fastened to the cardboard by rubber cement, staples, or Scotch tape. Although this method requires more preparatory work, it makes it possible to handle the cloth with much more speed and convenience during the printing and racking operations.

A celluloid guide is sometimes used on cloth and other flexible or irregular-shaped materials which cannot be accurately registered otherwise (Fig. 28). A thin piece of celluloid must be used, large enough to cover the area to be printed and yet allow sufficient margin for attaching one end of the celluloid to the base with cloth tape, to serve as a hinge for turning the celluloid back. The frame is lowered and an impression is made on the celluloid. Next, the material to be printed is registered under the celluloid after which the celluloid over-lay is turned back out of the way. All is now ready to lower the frame and make the impression on the cloth.

Occasionally a silk screen shop is called upon to change the lettering on a poster or display which has already been printed by some other method. In order to do this, it is necessary first to print over the original lettering with a heavy, solid color, then to print the revised lettering.



FIG. 29.—Paper flap guide.

It may be rather difficult to secure proper registration in the overprinting, especially if the displays are of irregular shape. The die-cutting of cutout displays, or the trimming of rectangular cards, is seldom done with exactitude. An examination of a number of examples will show considerable variation. Therefore, instead of registering such pieces under the stencil in the usual way by fitting the edges of the displays into the guides, it is necessary in such cases to disregard the edges and register by the lettering or some arbitrarily selected part of the display. This is done with the paper flap guide as shown in Fig. 29.

The display to be imprinted is first registered under the stencil. Then a piece of tough paper is attached to the base and made to extend to points on the display which may serve as convenient registration points. This paper

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guide is then folded back near the edge of the display. Before each impression, the display is adjusted in register under the flap after which the flap is turned back out of the way for the printing operation. It is, of course, essential that the paper used for flap guides be thin enough so that, when they are folded back, they cannot interfere with printing contact by bulking higher than the display. If the flaps are registered to some convenient point away from the imprint that is being made, the extra operation of folding the flap back before printing may be obviated.



For printing on thin paper, if very accurate registration is not essential, it is sometimes desired for expediency to put a number of sheets under the stencil at one time. In such cases, collapsible paper guides may be used, as shown in Fig. 30. As the stack of paper is gradually reduced, the lowering of the frame causes the guides to collapse to the level of the top sheet, until finally, when the bottom sheet of paper is reached, the guides will have collapsed flat on the table.

For work in one or two colors on cardboard, if only approximate registration is required, a stack of cards may be registered under the stencil in the following manner: In addition to using the collapsible guides above described, the screws in the hinges of the base are replaced by long bolts. The bolts will permit the printing frame to lie flat, in printing position, even though it is raised above the base to the height of the cards, and drop down gradually as the stack of cards is reduced.

STENCIL FABRICS

Silk.—Various fabrics have been tried for screen work, but none has been found so satisfactory as the silk bolting cloth which is used by flour millers and makers of other finely sifted materials. Bolting cloth may be obtained in widths of 40, 45, 50, and 54 inches, and in the following meshes:

| | | \mathbf{Mesh} | | \mathbf{Mesh} |
|-----|----------|------------------------|--------|-----------------|
| | | Count | | Count |
| No. | 1 | 48 | No. 11 | 116 |
| | 2 | 54 | 12 | 124 |
| | 3 | 58 | 13 | 130 |
| | 4 | 62 | 14 | 139 |
| | 5 | 66 | 15 | 148 |
| | 6 | 74 | 16 | 157 |
| | 7 | 82 | 18 | 170 |
| | 8 | 86 | 20 | 180 |
| | 9 | 97 | 25 | 200 |
| | 10 | 109 | | |

The various weights and strengths of the silk are dependent upon the number of strands that are contained in the threads. Two or more strands are twisted together, according to the weight or strength desired.

Bolting cloth is made in a full-gauze or a half-gauze weave. In the full-gauze weave, all of the warp threads are double and interlocked with the woof at each intersection. In the half-gauze weave, half of the threads in the warp are double and twisted around the woof. Fullgauze silk is woven up to No. 12 mesh. Meshes finer than No. 12 are woven with a half-gauze weave. In order to follow accurately the predetermined mesh sizes, it is necessary to use only half-interlocked double thread in the warp of the finer meshes.

In resist-stencil work, a fine mesh is necessary in order to obviate ragged edges in printing. For this work, No. 12 mesh will be found fine enough ordinarily, but for very fine work Nos. 14 to 18 should be used. As a general rule, the finer the detail to be printed, the finer the silk required. This rule must be employed with discretion, however, because if too fine a silk is used, the paint may not penetrate it easily. This is especially likely to happen if stiff and heavy paint is used.

With film or paper stencils a fairly coarse silk may be used, because these stencils will prevent any ragged mesh marks from appearing on the prints. If silk is used with these stencils, a No. 8 or No. 10 mesh will be satisfactory.

Silk is obtainable in standard, single-X, double-X, and triple-X grades, at a cost of \$4.00 to \$8.00 per yard. Triple-X is recommended where unusual durability is



required. The standard, single-X, and double-X grades are used for all ordinary work.

A special taffeta weave is also manufactured for use in screen printing. In taffeta silk, all of the threads are straight. Taffeta costs one-third to one-fourth less than bolting cloth. Taffeta is suitable for most kinds of work, but has not the durability of bolting cloth.

Organdy.—Many screen shops use organdy instead of silk, especially with film or paper stencils. Although the best grade of organdy is very much cheaper in price than the cheapest grade of silk, the ultimate cost of organdy is usually more than that of silk.

Organdy stencils consume about 20 per cent more paint than silk stencils, and will not last nearly so long. Organdy is also likely to become flabby after continued use, so that it is more difficult to secure hairline register. Metal Fabric.—Bronze, copper, or brass wire cloth is also suitable for use as screens. Although the first cost of wire cloth is very high, its great durability makes its use economical for some jobs. It is obtainable in widths up to 48 inches, costing from \$6.00 to \$9.00 per yard, and in meshes ranging from 100 to 250 threads per inch. Wire-cloth screens are particularly well suited for use with photo stencils. The photo stencils must be removed from wire screens by cleaning solutions which do not contain strong lye or acids which attack metals.

SQUEEGEES

The squeegee that is used to force the paint through the mesh of the screen consists of a heavy piece of rubber belt-



ing, bolted between two pieces of wood or panel board, with the rubber projecting beyond the edge of the wood about $1\frac{1}{4}$ inches.

The actual construction of a squeegee is simple enough to be performed by any amateur, but so much time is usually lost in shopping around for the proper kind of rubber that it is more economical to buy the squeegee ready-made.

Squeegees are designed for either one-hand or two-hand operation, the two-hand type being operated by grasping the squeegee at both ends. In the one-hand type, pressure is applied by grasping a handle in the center. The twohand type is used when a very long squeegee is required, because it may not be within the strength of the operator to distribute pressure evenly over its whole length by merely holding it in the middle. When a very long squeegee is

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used, it is better for two men to apply pressure—one at each end of the squeegee.

In the type of squeegee shown in Fig. 33, the rubber projects from both edges of the wood. The handle is detachable and may be fastened to either side, so that each edge of the rubber may be used.

The rubber used may vary in thickness from $\frac{1}{4}$ inch to more than $\frac{1}{2}$ inch, the thickness depending upon the work for which it is to be employed. For use with stiff, heavy paint, the squeegee rubber must be correspondingly stiff, in order to force the paint through the mesh of the screen.

For printing on soft, absorbent surfaces, a rather pliable rubber will be found most suitable.

It is not necessary, however, that beginners have a full assortment as, in most cases, a ³/₈-inch rubber will be satisfactory for all-round work.

The length of the squeegee should be slightly more than the width of the stencil, so



FIG. 34.—Squeegee sharpener.

that no side maneuvering will be necessary to direct the squeegee over the whole printing surface. If the squeegee is too small, it will be necessary to take two sweeps with it in order to cover the whole surface. This will leave a track of paint where the two strokes overlap. The one-hand squeegee is to be preferred whenever possible, because it is not so messy and dirty to handle as the two-hand type, and because it permits one hand to be free to hold down the frame when using a spring for counterbalancing as in Fig. 24A.

In order to prevent the squeegee from falling into the paint when not in use, the handle of the squeegee may be rested upon nails driven into the ends of the frame. If the frame is but slightly wider than the squeegee, the squeegee may be kept from falling into the paint by driving nails into each end of the squeegee and allowing them to project over the sides of the frame, as shown in Fig. 20D.

Before use, the rubber must be examined: if the edge is worn down, it must be sanded. To sharpen the blade properly, a long piece of garnet cloth or fine sandpaper is fastened on a table and the edge of the squeegee moved back and forth across it. Plenty of pressure should be applied evenly, and the squeegee must be held perfectly



FIG. 35.—Rolling-rack unit.

upright.

RACKS

Because of the relatively slow drying of the heavy paint used in this process, it is not possible to stack or slip-sheet prints in the usual manner as they come from the printing table. Means must therefore be provided to keep the prints separate until they are thoroughly dry.

Various systems are employed for this purpose, some of which are shown on pages 40, 41 and 42. A kind of rack which is to be found in practically all screen shops is shown in Fig. 35. The dimensions of a rack of this type may, of course, be varied to meet special requirements. A very practical size is 72 inches high, 56 inches long, and 30 inches wide. Wooden strips 1 inch wide and $\frac{1}{4}$ inch thick are used for crosspieces, which serve as shelves for the prints. Each rack provides shelves for 40 or 50 prints. In shops doing a great deal of printing on glass or metal, racks of this type are usually made of metal pipe instead of wood, and the shelves are made of heavy wire or wire netting. The rack should be equipped with castors, preferably of

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the rubber-tired variety, so that it may be rolled about as required. This type of rack may be purchased ready-made.

Prints made on thin paper are usually racked on a truck or dolly, similar to that shown in Fig. 36. A rack is placed



FIG. 36.—Loose racks on a truck.

on the truck, and each successive print is laid on the rack, until the truck is loaded.

Figure 37 shows an interlocking arrangement for stacking wet prints on the floor. This human

ing wet prints on the floor. This method is useful for amateurs who do not wish to build racks, and in commercial shops when all available racks are already filled. Stacking cards in this manner is a somewhat tricky procedure, however, because the whole stack may collapse and ruin all of the prints, unless the cards are properly arranged.

Figure 38 shows a long piece of furring in which nails are driven

1 inch apart. This nail-imbedded strip may be fastened to the wall at any required height from the floor, and the prints leaned against the nails as illustrated.



FIG. 37.—Interlocking stacking arrangement.

Figure 39 shows a simple drying arrangement for use when printing directly upon a long roll of cloth or paper. This consists merely of two wooden horses on which are placed long strips of furring, with light sticks or slats laid across at convenient intervals. Being movable, these



FIG. 38.—Simple upright racking arrangement.

crossbars may be spread out or condensed as occasion requires.

Shops which do not possess metal racks sometimes find it necessary to make prints on heavy glass, which cannot safely be shelved in ordinary racks. In cases where the



FIG. 39.—Racking arrangement for long flexible material.

printed design does not cover the whole surface of the glass, the glass is simply stacked on the floor with thin sticks between the pieces. Naturally, the sticks must be placed so as not to come in contact with the areas containing the wet paint.

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EQUIPMENT

STENCIL KNIVES

The cutting of film stencils requires a special tool known as a stylus, or film-cutting knife, which may be obtained at art-supply stores.

Only two or three knives are required, at least one of which should have a very reliable blade and should be reserved for cutting the finer detail. The other knives are for cutting broad outlines, cutting film to the proper size,

FIG. 40.—Film-stencil knife.

cutting paper stencils, and for general utility purposes. These knives may have heavier blades.

The cutting of stencils is a delicate operation requiring the very best of tools. The use of make shift knives for this work cannot be recommended. A honing stone should be kept on the work table and used frequently, to keep the cutting edges in perfect working condition.

The best knife for cutting film stencils has a very narrow blade about 1/8 inch wide, sealed rigidly in a handle. Swivel



FIG. 40a.—Utility and paper-stencil knife.

knives may be used for large work but, inasmuch as they are not easily controlled, they are of little use when cutting fine detail.

DRAFTING INSTRUMENTS

A set of drafting instruments will be useful in making original drawings and for making straight lines and perfect circles on stencils. For cutting circles on film, a blade, similar to that used in the stencil knife, is inserted in the compass in place of the lead. In lieu of a blade compass, the dividers may be used by flattening the end of one leg and giving it a sharp cutting edge.

THE SILK SCREEN PRINTING PROCESS

If the blades of the ruling pen are ground to a very sharp edge, the pen may be used to cut both sides of thin lines in one operation. In addition to the drafting tools there should be a 45-degree celluloid triangle, a steel rule, and a long iron bar, about 1 inch thick, with square edges. The iron bar is useful as a guide for sliding the triangle along when cutting vertical lines as its weight makes it less likely to shift position while in use.

LIGHT BOX

Although not essential in screen-shop equipment, a light box is useful in a number of ways. It is convenient to use



FIG. 41.—Light box. A. Frosted plate glass. B. Ventilators.

when tracing a drawing which is made on paper, for making photographic stencils, and for detecting pinholes and other imperfections in block-out stencils. It is especially useful when lettering is to be done in tusche directly on the silk, as it enables the operator to detect any spots not completely covered by the tusche.

The box may be of any convenient depth, and it should have a top of plate glass, preferably frosted, about 20 by

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30 inches in size. If the box is to be used in making photographic stencils, the distance from the light bulbs to the glass top should be approximately 24 or 28 inches, and it should be equipped with two 75-watt lamps for ordinary purposes and two 400-watt lamps for use when making photographic stencils. The box should also contain a red bulb of not more than 50 watts, as the use of such a bulb allows the operator to take his time in adjusting photographic copy under the stencil, since red light will not affect the sensitized surface. Then the 400-watt bulbs need not be lighted until everything is ready for the exposure. The box should be equipped with a separate switch for each set of lights. It will also be well to provide ventilators for the heat to escape.

LIGHTS

For night work, blue "daylight" bulbs, which give the nearest approach to natural light, make possible a much more accurate mixing and matching of colors. Their use will also reduce eyestrain.

Ordinary bulbs produce a distinctly yellowish light which alters the appearance of paint, so that colors mixed by ordinary artificial light, when checked later by daylight, appear quite different from the colors intended.

For the stencil cutter, a flexible gooseneck lamp fixture, which can be adjusted to any desired position, will be very helpful.

STEEL CABINETS

In the course of time, every silk screen shop accumulates a stock of paints, oils, varnishes, and thinners which, unless it is properly stored, creates a dangerous fire hazard.

Fire ordinances in most cities require that certain provisions be made against fires from this source; but even if the local law does not demand it, all paint materials should be kept in a steel cabinet. For the same reason, metal waste cans should be provided to hold waste rags saturated with these materials.

Rags soaked with turpentine should be disposed of with special care, because the possible presence of other oils is liable to cause such rags to fume or even burst into flame by spontaneous combustion.

It is also essential that the equipment include pails of sand and fire extinguishers. This precaution is especially necessary if the screen shop is in a building which does not have an automatic sprinkling system.

COATING MACHINE

Coating machines are used for varnishing finished prints and for putting a coat of paint over the whole surface of a quantity of cards or metal. Amateurs and small commercial shops usually apply over-all coats of paint or varnish by the usual stencil method, but, while this method is satisfactory for small quantities, it is neither sufficiently fast nor efficient for large quantity production. A great advantage of the machine is that it makes possible the use of spirit varnish, which gives prints a very high gloss. This type of varnish dries so fast that it cannot be successfully used for stenciling.

The operating parts of the coating machine consist of a set of motor-driven rollers, one of which revolves in a fountain containing the varnish or paint. This in turn is picked up by the roller and transferred by contact to other rollers, which equalize the quantity and distribute it to the cardboard or other printing surface.

PRINTING MACHINES

As printing by the screen process became more widespread, it was inevitable that competition and the consequent speeding up of production should bring up the question: Why not print by machine? This question has been answered by the development of machines of various types to meet specific problems, such, for instance, as print-

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ing designs on the curved surface of bottles and other glass articles. Some of the special equipment thus far produced has been rather costly and has often involved the solution of many technical difficulties.

Printing presses have been developed for printing on cardboard or other material of thicknesses up to $\frac{1}{4}$ inch, one such press being capable of turning out 1500 impressions an hour. In addition, many homemade devices have been employed to speed up printing and racking. One of these is a drum-shaped screen, which is operated somewhat in the manner of a mimeograph machine. Another consists of a foot treadle attached to the printing table for raising and lowering the stencil frame, so that the operator's hands may be free to handle the cards and squeegee without interruption. Endless-belt arrangements have been employed, with more or less success, to convey the prints away from the printing table to the racks for drying.

Up to the present time but few of these mechanical methods have come into wide use. This is not because they have proved unworkable, but simply because the average runs in screen printing have been too small to justify their For a run of, say, a few hundred cards, a press operatuse. ing at the rate of 1500 cards an hour would finish the run so quickly that more time would be spent in putting the stencil into the machine and removing it again than would be required for the actual printing. Furthermore, with prints coming from one machine at the rate of 25 per minute, another machine must be employed to rack them at the same speed. So far as the average commercial shops are concerned, mechanization of the process therefore seems unlikely for the present, but there are other tendencies to be noted which may make the use of high-speed printing equipment almost a necessity in the future.

Lithographers in growing numbers are finding it profitable to install screen-printing equipment for making imprints on posters, for printing light colors over dark ones, and for Other jobs which they cannot handle by other methods. Publishers are learning that many of the difficulties in printing book covers on pyroxylin materials can be avoided by the screen process. Printers are installing screenprocess equipment for printing small booklets on colored stock. Photoengravers are turning to the making of photo stencils for screen printing. Only time will disclose what changes these developments may produce in methods of screen printing.

MISCELLANEOUS

Shops which produce metal signs or backgrounds and displays for show windows have almost daily need of an airbrush and air compressor, for spraying paint, lacquer, or varnish, on displays. The airbrush is also useful for spraying shellac and lacquer when making paper stencils. If there is much spraying of lacquer to be done, the spraying equipment should be placed in a metal spraying booth to eliminate the fire hazard. An exhaust fan should be placed in the wall to remove the disagreeable odor of the lacquer solvents.

Portable electric cutting machines are convenient for cutting out small quantities of displays, where the cost of die-cutting would be prohibitive.

In shops where many resist stencils are used, much time may be saved by having a metal tank in which to wash the filler out of the screen when a stencil is no longer needed. Clearing of the screen may also be facilitated by the use of a rubber hose with an adjustable nozzle.

Other items of daily use in screen shops include a paper cutter with at least a 30-inch cutting blade, either handoperated or power-driven; and, if large quantities of work are to be done on felt, velvet, or other kinds of cloth, an electric cloth-cutting machine is necessary.

Racks should be provided for storing printing frames and squeegees when they are not in use. Files or shelves should also be provided in which to keep original drawings, samples of completed jobs, and stocks of paper and cardboard. In addition to benches or tables for laying out the work, there should be drawing tables and the necessary materials for producing the art work. In connection with the production of drawings, a pantograph or projecting machine is useful on occasions when it may be necessary to make an enlarged reproduction of a small drawing.

CHAPTER III

PRINTING MEDIUMS

JAPAN COLORS

Most of the early screen printing was done with paints ground in japan drier, the so-called coach colors. These colors possess excellent covering quality and dry with complete opacity, even when rather thinly applied. This feature is very desirable for printing on glass, especially if the work is to be looked at through the glass toward the light, in which case any imperfections in the printing will give the effect of pinholes.

Ground exceedingly fine as they are, japan colors produce prints which are very clean and sharp. They are, however, inclined to dry too fast for process work. It is customary, therefore, to retard their drying by the admixture of castor oil, boiled oil, linseed oil, litho varnish, or any one of several other heavy slow-drying varnishes. Too liberal a use of varnish must be avoided so as not to retard drying unduly and slow up the printing operations. An excess of varnish may also cause a slight oil ring to form around the printed areas. If the addition of heavy varnish makes the paint too "tacky" or stiff, a small portion of turpentine should be added. In fact, japan colors are usually made up so thick that it is seldom possible to thin them enough for use merely by the addition of varnish.

If paint is left in an open can overnight, a scum or crust forms on its surface. To prevent this, the paint should be kept covered, or just enough oil should be poured on to cover the surface of the paint.

OIL PAINTS

Most of the screen work today is printed with oil paints especially prepared to meet the requirements of this particular process. These paints are called process paints, and may be obtained in a wide range of colors from practically every supply house. They come in paste form at prices ranging from \$2.00 to \$7.00 per gallon, depending upon quality. Cheap brands of paint are often made by substituting cheap fillers for the expensive pigments, in varying proportions. For first-class work it is more economical in the end to use only first-grade paints. Black and white, being fundamental pigments, are cheaper than the other colors; mineral orange, purple, gold, silver, magenta, and turquoise blue are comparatively expensive.

When selecting oil colors for screen work, one should most decidedly not be content to employ makeshift materials. Only those colors should be used which are prepared especially for the purpose. When a few cards must be gotten out hurriedly, it may be possible to use ordinary house paints in the emergency; but if one tries to use them for long runs he will find that they dry too rapidly, that they lack the required consistency, and that the coarsely ground pigment clogs the mesh of the silk. All this wastes the operator's time, exhausts his patience, and makes the work more expensive than if proper materials had been selected at the beginning. Homemade, hand-ground paints are even less suitable for good process printing.

For work requiring a hard yet flexible surface, with a gloss or semi-gloss finish, a long oil varnish should be added to the paint. The term "long" is applied to colors ground in dammar, rosin, and the various copals, such as kauri, Manila, etc., synthetic resins being widely used. If a high gloss must be produced, paint should be thinned with a special gloss varnish.

Short colors are prepared with the same materials except that oleum spirits are added to make the colors dry flat; that is, with a matt finish.

Long colors are soft and fatty; short colors are stringy and slow flowing.

A complete list of paints and accessory products for the well-equipped screen shop that has not a readily available source of supply would include the following: Tinting white, printing white, or super white; lemon yellow; chrome yellow; orange; light red; deep red; rose red; cerise red; magenta; purple; cerulean blue; ultra blue; deep or navy blue; emerald green, chrome green; black; silver; gold; reducing varnish; turpentine; transparent base (for sharp printing and transparent effects); overprint varnish to produce gloss by overprinting.

METALLIC PAINTS

Gold, bronze, and silver lining powders may be very successfully employed in printing by the screen process, and if properly prepared, they retain the luster characteristic of metallic paints. The powders may be purchased in a great variety of shades and colors.

When applied by the screen process, metallic paints are opaque. This makes it possible to print them solidly over dark colors in one operation. It is not possible to do this by lithography or by any of the other printing methods.

Instead of buying metallic paints ready mixed, the powder and varnish should be purchased separately and mixed as needed, preparing only enough for immediate use. They should be prepared by stirring the metal powder into a small quantity of turpentine, and then adding a heavybodied flat varnish. The screen should be drum-tight and of a coarse mesh. The brightest gold is pale lining gold.

PROCESS WATER COLORS

If desired, process water colors, or tempera colors, ground in glycerin and gum, may be substituted for oil colors. Besides being cheaper than oil colors, these paints dry faster and with the brilliance and soft matt finish characteristic of tempera colors. They are usually overprinted to produce transparent effects.

Some brands of process water colors are claimed to be waterproof; others are claimed to be merely water resistant. Either honey or molasses may be used to retard drying,

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since water colors generally have a tendency to dry too fast. Under normal conditions, prints should dry in 30 minutes to 1 hour. Special preparations to extend the colors and to regulate their plasticity and drying quality are also obtainable. It is not advisable to experiment with ordinary tempera colors for process printing by merely adding glycerin to them, because the results are seldom satisfactory.

Most process water-color reproductions tend to dry out in time, leaving the printed surface full of fine cracks in a weblike pattern. Other objections to water colors are that they fade more rapidly than oil colors; they are likely to "bleed" when superimposed; they are less opaque than oil colors; moisture in the colors sometimes makes the cardboard warp; water-resistant screens must be especially prepared for their use; they are easily marred, so that it is usually necessary to slip-sheet the prints to prevent their being damaged by rubbing. Furthermore, once the color clogs, it is very difficult to remove it from the screen.

DYES

If dyes are to be used for screen printing, their liquid character makes it necessary first to add a thickening agent, which by coagulating gives body to the dye, so that it may be squeegeed. There are numerous substances used for this purpose, among them being gum tragacanth, starch paste, wheat-flour paste, dextrin, and British gum. Inasmuch as cloth is not hardened by the dyeing operation, it retains its original pliability and softness. Most dyes have a tendency to fade, particularly if exposed to sunlight. They must, therefore, be specially fixed to render them fast as well as washable.

Since the colors are naturally transparent, one color may be printed over another so as to produce a third hue. This is called "trapping" the colors. In this way, five or six colors may be obtained from three printings. Acid dyes present a special problem for the silk screen printer, because the acids employed have a very destructive effect on all kinds of stencils except those made with bakelite varnish. However, there has recently been put on the market a new type of stencil preparation which, it is claimed, resists the solvent action of acid dyes.

The commercial preparation and use of dyes involve many problems in chemistry, and textile plants employ experienced chemists to supervise this work. Although screen printing with dyes is discussed in another chapter, the chemistry of dyes is outside the scope of this book and those who are interested in the use of them are advised to consult books relating specifically to dyes and commercial textile printing.

ENAMELS

Special enamels are obtainable for screen printing, their use being confined mostly to work on wood and metal for outdoors displays. They are applied like regular process paints; hence, special preparations for their use are unnecessary.

Porcelain enamels to be baked on metal are of an entirely different nature. They consist of pigments combined with glass, silicate, borax, and various metallic oxides and can be applied only in enameling plants which are equipped with special baking ovens to fuse the enamel with the metal.

LACQUERS

For certain kinds of screen printing, the popularity of lacquer colors is growing rapidly. Lacquers are used principally on oilcloth, lampshades, decalcomanias, novelty furniture, glass, and metal. Special lacquers are also obtainable for printing on textiles.

Lacquers are supplied in many standard colors as well as waterclear, and in either paste or spraying consistency. They are very brilliant, drying with a normally high gloss. However, flexible lacquers and lacquers which dry with a dull finish are also obtainable.

Owing to the extremely volatile nature of the solvents employed, lacquers dry very quickly. Screen-printing lacquers should dry within 1 hour.

Lacquers have less body than oil colors, and so it is not customary to print one color over another except when it is desired to produce a third color. Their transparency makes it possible to produce a wide variety of colors by using only the red, blue, and yellow primaries. Striking results may be obtained with them by printing four-color half-tone work from photo stencils on soft paper. All surfaces which are to be printed with lacquer must be thoroughly dry and free from grease.

Lacquer manufacturers use various gums and resins as binders for the pigments, some of them being gum elemi, gum dammar, and copal, kauri, Manila, and ester resins. The principal solvents used are amyl acetate, ethyl acetate, and acetone. Wood alcohol, benzol, butyl alcohol, toluol, petroleum naphtha, and denatured ethyl alcohol are also used as diluents.

To reduce shrinkage, puckering, and brittleness, various plasticizers are used such as castor oil, tung oil, tricresyl phosphate, butyl stearate, and dibutyl phthalate. Castor oil, tung oil, and rapeseed oils are also used to make lacquers dry more slowly.

The principal objections to the use of lacquers, aside from their greater cost, are their inflammability and the disagreeable odor of the solvents employed. Fire ordinances in most cities require that lacquers be used only in special fireproof rooms.

TRANSPARENT BASE

Transparent base is a jellylike preparation which is made of alumina stearate, alumina palmatate, or other similar material. It is mixed directly into the paint and



FIG. 42.—Poster employing transparent colors to produce additional colors or shades.

is used in screen-printing shops for several different purposes, namely:

1. For thickening the color. If, through accident or miscalculation, the paint is made too thin, the desired thickness may be restored by the addition of transparent base.

2. For making oil colors shorter. Occasionally the paint is too fat; that is, it contains too much oil and is not short enough. If used in that condition, the color will blur and spread on the print. The addition of transparent base will increase its viscosity, making the color print clear and sharp, even on nonabsorbent material.

3. For producing transparent colors. If a color is made transparent, another color may be superimposed upon it to produce a third color. Transparent colors are also used with photo stencils to reproduce paintings, colored photographs, etc., in color-separation work.

Although printing with transparent colors has already been referred to in the printing of dyes and water-color paints, it may be well here to describe certain operations more specifically. If, for instance, it is desired to obtain yellow, blue, and green from two printings, the yellow is printed first and then the blue is printed over the yellow. The area where the two colors overlap will be green. The order in which colors are printed will affect the hue or tone which results.

If transparent colors are to be used extensively it is well to have a color chart which will show the effects produced by all of the possible different color combinations. Such a chart may be made in the shop, and can sometimes be obtained from the dealers.

When extreme transparency is called for, it is advisable to start with the base, adding color gradually until the required effect is obtained. In such cases, a practical method is to add regular transparent litho ink of great intensity to the base. The ink will tint the base to the required hue while the varnish in the ink will increase the luster, ultimately producing a very fine finish.

THE SILK SCREEN PRINTING PROCESS



FIG. 43.—Fashion figure printed with transparent colors.

When base is added to paint merely as a shortener, care must be exercised to determine just how much of it may safely be used with various colors without affecting the opacity of the paint. If the paint is very heavy and solid, it will stand the addition of much more base than will a color naturally lacking in body. For example: when printing red over dark blue, the red will appear brownish if too much base is added to it.

The paint and base must be stirred until the two are thoroughly mixed. Black, being a very intense pigment, will safely stand the addition of a large amount of base before losing its true character.

The important difference between the action of base and that of a thinner, such as varnish, is that paint, diluted with thinner, loses its consistency and becomes more liquid; mixed with base, however, the chroma is weakened, but the paint does not become more liquid.

THICKENING AND DOPING AGENTS

Extender or mixing white is a putty-like substance, used to build up or add body to paint and increase its coverage. This is known as "doping" the paint. Extender is also used to change the hue of the color. For this purpose it is more economical than transparent base but not so effective.

Extender costs about half as much as paint, so one reason for its use is obvious. Using too much extender may result in weakening the paint. For work involving large printing areas, extender may safely be used in the proportion of one part full-strength paint to one part extender.

The employment of extender in paint makes it fade more readily; therefore it should be used with discrimination. If the printed work is to be displayed in sunlight, unadulterated colors should be used. Fugitive or quick-fading colors, such as magenta, peacock blue, rose red, cerise, lavender, and some of the light greens, should be used only full strength if they are to withstand the elements.

Another material which is frequently used for doping the paint is sodium silicate. This may be purchased at drugstores in the form of a white powder or as a thick liquid. In the latter form it is commonly known as water glass. When the powder form is used, it should be added to the paint gradually and stirred until the two are thoroughly mixed. Failure to do this will cause the silicate to separate from the paint and form a sandlike residue on the stencil. Water glass works more rapidly than the powder, just a few drops being sufficient to thicken a gallon of paint within two or three minutes. The liquid is not used as an extender, to increase the volume of the paint, but merely to thicken it when it is too thin for sharp printing. The powder is used both to thicken the paint and to increase its volume. Since sodium silicate reduces the flexibility of paint, making it more brittle and flat, it should be used only when extender is not available.

Various inert substances, such as whiting, linolith, asbestine, cornstarch, and carbonate of magnesium, may also be used as thickeners. For the average shop, however, cornstarch is the most practicable material, as all of the others must be ground the same as paint. Cornstarch has the same tendency as sodium silicate to form a gritty deposit on the screen. If a small amount of cornstarch is used, it will act as a shortener by absorbing some of the fatty oil in the paint.

CLEANING MEDIUMS

Kerosene and turpentine are most generally used to remove paint from the stencil and to clean the squeegee, frame, etc., at the end of a run. Kerosene is mainly used for washing because it is cheaper than turpentine and is just as effective; but in some cases turpentine is preferred because of its quick drying property.

A cheaper variety of turpentine, known as sub-turpentine, may also be used.

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Other washing mediums are alcohol and lacquer thinner, alcohol being employed to remove shellac from the silk, and lacquer thinner to dissolve film and lacquer stencils.

Gasoline may also be used, but it is not so popular as kerosene because of its odor, inflammability, and greater cost. Naphtha and benzene may be used for cleaning purposes but they evaporate much too rapidly.

DRIERS

Turpentine and japan drier are the mediums most used in commercial shops to make the prints dry rapidly. Oxide of cobalt, oxide of lead, oxide of manganese, sugar of lead, litharge, or copperas may also be used. Where there is a lack of adequate racking equipment, benzol is sometimes added to the paint because it is very volatile, being known as "lightning drier." Driers are not used so extensively today as they were in the past, because the process paints now made especially for screen printing usually contain the proper drying ingredients.

VARNISHES

Varnishes may be divided into two classes: those which are used to reduce the viscosity of the paint, and those which are used to produce a gloss on the finished prints. Varnishes are also classified as slow-drying and fast-drying. When buying varnish it is well to explain for what purpose it is to be used, so that the dealer may supply a varnish adapted for that particular need.

For producing a glossy finish, there are oil varnishes and spirit varnishes. Linseed-oil varnishes dry more slowly and give as high a luster as the spirit varnishes, but they are less brittle and much more permanent. Spirit varnish is not durable enough for long outdoor use. This varnish must be applied by the coating machine, as it dries too fast for stenciling.

Overprint varnish dries in a few hours with a very high gloss. Lithol varnish, the early favorite of screen printers, has now been replaced by varnishes which dry faster, except for work on tire covers, artificial leather, and other materials where great flexibility is required. Overprint varnish works very well on coated stock, or on stock whose surface has been entirely covered with paint. However, if overprint varnish is applied to a white stock, it will discolor the area and give it an undesirable mottled appearance. To counteract this, it may be necessary to print white wherever white must appear on the finished work. Spirit varnish has a less detrimental effect on white cardboard, except to produce a very slight yellowish or grayish cast to the stock.

For signs which are to have a sanded or smalt finish, the base coat of varnish may be applied very economically by the screen process. The varnish can be stenciled on either background or lettering, as may be required. Before the varnish dries, the stenciled area is dusted with smalt. Although smalted signs are not so popular as they formerly were, there are still occasions when they are successfully employed. In quantity work, a great saving in time will result when the stencil method is employed and the varnish is used like any other printing medium.

PAINT THINNERS OR REDUCERS

Since process paints usually come prepared in paste form, it is advisable to thin them before they can be successfully squeegeed. The varnish selected for this purpose should be of medium drying quality, that is, one which dries neither too fast nor too slow.

Kerosene and turpentine are also used sometimes for thinning paint, but their use is not recommended. Kerosene makes the paint dry more slowly and with a flatter effect, slightly changes the hue of the color, and "cuts" the paint. Kerosene, if used to excess, may cause oil rings to form, especially on coated paper. Turpentine also makes the paint dry flatter, and robs it of some of its adhesive quality. Being volatile, turpentine gradually evaporates, making the paint thicken with extended use. It should be avoided because, since it makes the color dry too fast, the paint may dry into the screen and clog the mesh. For the same reason, neither naphtha nor benzene should be used, unless the paint is so slow-drying that something is absolutely necessary to hasten the process.

As a thinner, turpentine, in small amounts balanced well with varnish, is more satisfactory than varnish alone. Its flatting quality is somewhat desirable on paper posters, but is undesirable on high-grade cardboard displays. Lettering that appears in flat colors on paper window posters is more legible in strong light than if it has a semi-gloss or lustrous finish. Counter displays look brighter and more cheerful when the color is not flat.

LACQUER THINNER

The solvents employed in lacquers are very volatile and their rapid evaporation when exposed to the air makes it necessary to add a thinner to keep them at workable consistency. The thinner is also used to remove film stencils from the silk at the end of a run.

Each lacquer manufacturer prepares his product for use with a certain type of thinner, and so, for best results, it is advisable that the thinner be supplied by the maker of that particular lacquer.

GLUE

Glue can be stenciled as easily as paint and so has several useful applications. For a quantity of display cards on which tinsel, felt dust, flitter, etc., is to be applied to the design or the lettering, a great deal of time may be saved by making a stencil and squeegeeing glue on the desired area. The tinsel or other material is then dusted on the card while the glue is still tacky. Surplus material may be brushed off after the glue has set and dried. This method is used extensively for producing novel effects on Christmas signs, albums, captions, etc. The stencil method is also used for applying glue to the back of posters and displays, for the attachment of easels or labels, and for many other purposes. When processing glue, either a lacquer, shellac-film, or varnish stencil must be used, because a glue stencil would dissolve immediately.

ASPHALTUM

Asphaltum is a tarlike substance which is stenciled on glass or metal, to act as a resist when etching solutions are applied. The thinner to use with asphaltum is turpentine.

GLASS-ETCHING COMPOUND

This is a product recently put on the market for frosting designs on glass. It can be applied with a stencil and etches the glass in a few seconds.

GOLD SIZE

The regular gold-leaf size which is used by sign painters as the base to which to apply gold leaf may be successfully stenciled. The gold is applied to the tacky varnish in the usual manner. When the varnish is applied by the stencil method, the work is faster, more econonical, and more uniform.

CHAPTER IV

PRINTING SURFACES

DEVELOPMENT

In the early years of its development, screen printing was limited solely to such materials as could be laid on the printing table under a flat stencil, and was employed chiefly for banners, posters, and displays for advertising purposes.

Two important developments have been responsible for the rapidly widening use of the screen process on industrial products within the last few years. The first was the development of the special stencil film. Although much fine work had been done with the block-out and resist stencils, most manufacturers felt that work produced by those methods was not quite sharp enough for use on manufactured articles. However, manufacturers soon learned that, by using stencils made with this film, prints could be made practically as clean and sharp as those obtainable by letterpress printing.

The second development came through the discovery that the screen process can be employed for printing on all sorts of curved or irregularly shaped articles, provided that the designs to be reproduced are kept to simple patterns not necessitating very fine registration. Now, all kinds of odd-shaped stencils are being used. In some unusual cases the stencil, frame, and squeegee may be made to conform to the curved surface of an object; in other cases, flat stencils are used for printing on round objects, the bottle or other article being made to roll under a stationary stencil.

Where the volume of work to be done has justified the cost, expensive machinery has sometimes been built

THE SILK SCREEN PRINTING PROCESS



FIG. 44.—Examples of printing on curved glass surfaces with paints, lacquers, and ceramics.

especially for processing purposes. It would not be helpful here to enter into a description of equipment so complex,



FIG. 45.—Advertisement printed directly on a feather—one of the many unusual surfaces on which it is possible to print by the screen process.

because each printing problem of this sort requires its own individual solution.

Although the construction of stencils and squeegees may differ very much for materials of various shapes, the problems that arise due to texture of the various printing surfaces are relatively few. Therefore, it will be sufficient to consider here the characteristics of only those materials in general use.

In the main, all printing surfaces fall into one of two classes; that is, they are either porous and absorbent, or nonporous and nonabsorbent. Porous surfaces quickly absorb the paint like a blotter, thus counteracting any tendency of the paint to spread. Designs printed on soft paper or cardboard will, accordingly, appear sharper, and will more nearly approach the character of letterpress



FIG. 46.—A window streamer printed on sulphite bond.

printing. Soft surfaces usually require the use of soft squeegees and rather free-flowing paint; hard surfaces require stiffer paint and a stiffer squeegee.

From this it is clear that different surfaces require different printing mediums as well as special make-ready. Certain types of work are more satisfactory when flatdrying paint is used; others require the addition of gloss varnish. A wood or metal outdoor sign may be made more durable by being printed with enamel. Other kinds of material may justify or make necessary the use of lacquer. When the operator is confronted with a problem concerning the printing medium, it is best for him to consult his supply dealer, who will usually furnish all possible technical assistance in such matters.

PRINTING SURFACES



FIG. 47.—Book jacket printed on paper and wrapped around a giant wooden dummy for advertising purposes.

PAPER

The screen process may be successfully employed for printing on all kinds of reasonably smooth paper, including



FIG. 48.—Advertising figure printed on gold metallic paper.

blotting paper, kraft paper, crepe paper, litho paper, bond, highly coated stocks, etc.

For printing and imprinting 3-sheet and 24-sheet posters, for printing streamers, window signs, and various other inexpensive signs, thin white sulphite bond and litho paper are the most widely used.

Litho paper may be obtained in rolls of various widths and grades, as well as in sheets cut to specified size. Bond paper is obtainable in transparent and standard thicknesses, in rolls 12, 18, 24, 30, 36, 48, and 60 inches wide. Each roll is 50 yards long.

Because of the greater absorptive quality of paper, paint dries on it faster than it does on cardboard. The thinness of paper makes it necessary to guard against any unevenness of the printing base.

Light colors appear purer and more brilliant when printed on white paper than when printed on colored stock.

Paint or lacquer may be stenciled on silver, gold, bronze, or other metallic papers. The paint should be rather short and heavy, and contain a good binding varnish to reduce brittleness. Brittle colors do not hold well and are liable to get chipped off or scratched.

For printing lampshades and translucent signs, especially prepared parchment paper may be purchased in large or small quantities, all ready for printing. The various sizes of the sheets are: $22\frac{1}{2}$ by $28\frac{1}{2}$, 20 by 36, 21 by 31, 24 by 36, and 24 by 38. When purchased in small quantities, the 24 by 36 size costs about \$10.50 per 100 sheets, and the cost of the other sizes is proportionate.

BOARD

By far the greatest amount of screen printing is done on paper or cardboard, with cardboard predominating. Of the several different types of cardboard in general use, the most common are newsboard, chip board, show-card, container board, corrugated board, and lined board.

Cardboard, as well as paper, has a definite grain, and it curls and warps parallel to the grain more readily than it does across the grain. This point is important to bear in mind when printing upright displays. If the long dimension of the display extends vertically and across the grain of the board, for example, the curling action from the top and bottom may cause the display to fall over; whereas, if the grain runs vertically, the curling or warpage will be from the sides, and so will cause but little damage to the appearance of the display. The direction of the grain in cardboard may be ascertained by bending a piece of it along the edge. When bent parallel with the grain, it is noticeably more flexible than when bent across the grain.

Lined Board.—Lined board is a type of stock on which a very thin paper is mounted on both sides of substantial cardboard. Lined board may be secured in pure white, which usually makes for the best looking job. Another advantage of white lined board is that, if the design to be printed includes a white area, the color of the card makes the printing of white unnecessary. When ordered in large quantities, lined board may also be obtained in any desired color.

One drawback to the use of lined board is its tendency to shrink, rendering fine registration difficult despite any precautions one may take. The reason for this annoying shrinkage is that, after the liner is applied, the board is sometimes shipped from the mill without being given time to season properly. The operator should insist that the dealer furnish stock known to be thoroughly seasoned. It is well to take this precaution not only with lined board, but with other kinds of stock as well.

Newsboard.—Newsboard is a much cheaper stock than lined board and does not appreciably shrink or expand. It is obtainable in a large assortment of weights and sizes and is kept in regular stock by many supply houses.

Since this board is usually grayish in color, one of the light colors appearing in the design should be first printed over the whole surface of the card. Coating the entire surface of the board in this manner makes for smoother printing, greater opacity, and greater brilliance. Initial coating of the entire board is often omitted, however, when large runs are to be printed, in order to economize on the paint. In such instances, the different colors are stenciled in turn directly on the uncoated board.

Newsboard is supplied in the following standard sizes: 26 by 38, 29 by 45, 33 by 44, 40 by 60, and 38 by 50. Standard thicknesses, measured in points, are as follows: 30, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, and 200. Since one point equals $\frac{1}{1000}$ inch, 100-point stock is $\frac{1}{10}$ inch thick.

In very small quantities, newsboard is sold in 50-pound bundles; in large quantities, it is sold by the ton. One 50-pound bundle will contain, on the average, 17 sheets of 100-point stock, 30 by 40.

Chip Board.—Chip board is similar to newsboard but is inferior in quality. Its surface is covered with numerous colored flakes or chips which render it difficult to produce an even printed tone.

Show-card Board.—One advantage in printing on showcard stock is that, in addition to white, it is easily obtainable in many colors. The use of the white board for designs in which large areas are white eliminates the necessity of printing that color. Similarly, colored show cards are frequently used in order to eliminate the necessity of printing the background color.

Show card is a smooth, thin board and is very satisfactory for printing small quantities of cards of moderate size. It is supplied in sizes 22 by 28 and 28 by 44, in 50-point and 100-point thickness, in many standard colors. It is also supplied in sizes 30 by 40 and 40 by 60, in white only.

Container Board.—Container board is a thin, toughfibered board used for cartons, containers, and other articles which are subjected to bending or folding. Its color is usually buff or light brown. In order to overcome the intensity of the natural color of this board, it is necessary, when printing, to use paints of a heavier and more opaque quality than those used on lined board or coated board.

THE SILK SCREEN PRINTING PROCESS



FIG. 49.—A corrugated-board shipping container made pleasingly decorative in two colors.

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FIG. 50.—A floor-stand merchandise display made of corrugated board and printed in two colors.

Corrugated Board.—Corrugated board is used for collapsible floor-display stands and for shipping cartons. It may be obtained in natural brown and in numerous colors. When it is necessary to print designs and advertising displays on this type of material beautiful results are obtained with the silk screen process.

Advertising displays may also be printed on flat paper or thin board, then run through a corrugating machine to produce a novel effect.

GLASSY SURFACES

Glass.—Glass is perhaps the most difficult of all printing surfaces and requires the most skill in the preparation of the paints and in printing.



FIG. 51.—Illuminated electric flasher display. The dark portions of the display were printed with opaque paints. The light portions were printed with transparent lacquers to produce the illumination when the lights are flashed on.

None but the very best quality of paint should be used for printing on glass surfaces. Japan colors, oil paints, enamels, and lacquers may be purchased which are prepared especially for processing on glass. If the finished work is to be placed where the glass will become heated due to its proximity to strong electric lights, it will be best to use special non-brittle, heat-resisting colors.

Because of the nonabsorbent nature of this material, the paint used should be stiffer than that used on any other kind of surface, so that the paint will not spread. The layer of paint deposited on the glass is naturally a heavy one and will be somewhat slow in drying. This is not altogether undesirable, however, because, if the paint were to dry too fast, it would probably chip off by reason of its brittleness.

To ensure clean printing, the squeegee rubber must be stiff and sanded down to a sharp edge. The glass should be scrupulously clean and free from grease. Just before printing, the glass should be cleaned with a rag dampered with alcohol. This is especially necessary if the finished work is to be looked at through the glass toward the light: tiny spots caused by particles of dust or other foreign matter would show up as glaring imperfections.

When printed matter is to appear on the back of a glass sign, the usual sequence of colors should be reversed; that is, the color printed first must be the one ordinarily printed last. In this case, the lettering must be printed backward so that, when viewed from the front, the lettering will read correctly.

Unless the silk is properly protected, the sharp edge of the glass may cut the stencil. To avoid this, the silk should be reinforced with gum tape where it comes in contact with the edge of the glass, and additional protection may be provided by covering the gum tape with lacquer or shellac. Because of the greater wear and tear on the stencil in printing on glass, the screen should be made of silk and not organdy.

Drawing a file or piece of sand paper along the sharp edge of glass will round it off so that the edge is blunted and less liable to cut the silk.

Perhaps the best method for avoiding injury to the silk is as follows: Place the piece of glass to be printed in the correct position under the stencil. Then attach cardboard



FIG. 52.—Display printed in white on cellophane and wrapped around material of a stiff, coarse texture.

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PRINTING SURFACES

to the base at all four sides of the glass and build up the cardboard until it is exactly even with the top of the glass. In this way, the squeegee moves across the screen smoothly, and there is no impact with the glass which would cause damage to the silk. When the glass is surrounded by cardboard in this manner, it is necessary that the cardboard have slots or notches cut in it to enable the fingers to grasp the edge of the glass for insertion and removal.

Recently ceramic colors have been placed on the market for industrial use in decorating bottles and household glassware. These colors are subjected to baking, which fuses



FIG. 53.—Example of printing on celluloid. The background was printed with opaque silver paint, the outlines of the figures being printed with black on the clear celluloid.

them into the surface of the glass, thus making them an integral part of the object.

Celluloid and Cellophane.—Celluloid and cellophane, being nonabsorbent materials with glasslike surfaces, require practically the same general treatments as those used with glass, except that their edges are less inclined to injure the silk. Because of the flexibility and flimsiness of thin sheets of celluloid and cellophane, it is ordinarily very difficult to handle and register them accurately in the guides. If close registration is necessary, it is advisable first to mount the sheets temporarily on substantial cardboard by tipping them at the corners with rubber cement or Scotch tape. Ordinary process lacquer should not be used on these materials because the solvents which are used in lacquer are also solvents of celluloid and cellophane.

OILCLOTH, ARTIFICIAL LEATHER, ETC.

Printing on tire covers, oilcloth, artificial leather, linoleum, and similar materials requires printing mediums which possess the same clinging and adhering quality as those used on glass. The medium used must also have the necessary properties to make it cling to the surface without cracking or chipping when the material is rolled, folded, or creased.

For processing on tire covers, the printing medium must have enough opacity to prevent the original black color of the material from showing through. As in printing on glass, the color should contain enough long-drying varnish to avoid brittleness. Special tire-cover paint and flexible lacquers which do not require any special preparation may be obtained for printing on this type of material.

Like celluloid and cellophane, the materials named above should be tipped on cardboard before printing to facilitate registration and handling.

CLOTH AND FELT

Stenciling cloth signs, banners, show-window backgrounds, counter pads, pillow tops, pennants, emblems, awnings, caps, arm bands, etc., is comparatively simple. The paint used may be rather free-flowing, because these fabrics readily absorb the paint, forestalling any tendency it may have to spread.

For scarves, dress material, draperies, table covers, wall decorations, and other household or utilitarian fabrics, paints are not recommended because they make the material somewhat hard and stiff. In the past, dyes have been used exclusively for the printing of fabrics, but now certain lacquers made especially for printing on textiles are obtainable. These lacquers are pliable when dry and do not perceptibly stiffen the fabric. The subject of textile printing is considered at length in another chapter.

To compensate for the slight unevenness in the material, the squeegee rubber should be flexible enough to fill in tiny irregularities of the surface.

Printing on cloth, unlike glass and cardboard, requires practically no equipment for racking the finished prints, because the paint is absorbed into the fabric so quickly that there is little danger of the colors offsetting, so long as no unusual pressure is applied. If there are 200 prints to be made, for example, the first ten may be laid flat on the floor separately, and then succeeding prints laid flat over them in rotation.

When printing on velours, suede, velvet, and other heavy-pile fabrics, it is sometimes necessary to run the squeegee over the stencil several times, in order to deposit enough paint to fill the nap of the material, and so leave an even, clean impression.

METAL

All kinds of metal signs, display racks, stands, and cabinets are printed by the screen process, either paints or lacquers being used.

Black sheet metal is used more than any other metal, although cold-rolled, annealed, galvanized, and galvannealed sheets are also used. Galvanized metal is not recommended for permanent signs unless it is specially treated. Several preparations are obtainable for rendering the surface of galvanized metal suitable to receive the paint. One of these preparations may be made as follows: Dissolve 1 part copper chloride, 1 part copper nitrate, and 1 part sal ammoniac in 64 parts water; to this, add 1 part commercial hydrochloric acid. Apply with a brush.

For temporary work, colors are sometimes printed directly on the raw metal. If permanence is desired, black sheet metal should first be immersed in dilute sulphuric or muriatic acid to clean the sheet thoroughly. Firing to

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red heat should follow, and then a generous scrubbing to remove the scale completely. The last traces of acid should be removed by a bath in boiling soda solution. Scouring with a wire brush or sandpaper and washing with hot water may follow, to give the metal a chemically clean surface.

For small runs, black metal may be purchased already covered with a priming coat in yellow or white, ready for printing. These sheets are supplied in sizes 20 by 28 and 20 by 36, from 20-gauge stock, which is the heaviest, to 38-gauge, which is the thinnest.



FIG. 54.-Metal hanger cut and bent to display merchandise effectively.

Before being processed, all metal should have a priming coat on both sides, applied by dipping or spraying, and baked in for at least 1 hour at 250°F. If the signs are to be exposed to the weather, or otherwise subjected to hard usage, all of the colors should be oven baked, to fuse the paint with the metal and so make the work more durable. The background should be coated with baking enamel and baked at about 180°F. for 2 hours. Long oil process colors may be used for stenciling the design, which is then baked for 2 hours at 130° to 150°F.

Some manufacturers prefer aluminum paint as the priming medium, because of its durability and resistance to

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moisture and to chemical fumes. The binder is the same as is used for paint, with spar varnish added. Aluminum lacquer may also be used, but must be sprayed on.

For indoor work, the oven baking is sometimes omitted, the colors being only air dried. For the background, long or semi-long process colors are applied by spraying, stenciling, or machine coating over the dry priming coat. The same paints are used for processing the design. A finishing coat of varnish is good but not essential. However, if the processing is done with short oil colors, the finished work must receive at least two coats of spar varnish.

When stenciling metal, care must always be taken to protect the silk from injury by any rough edges of the metal. This is usually done by building up around the metal with cardboard in the same manner as is recommended when printing on glass.

Lacquer pastes, costing slightly more than oil colors, are now widely used for work on metal. Their quick drying shortens the time required for the processing operations and the natural high-gloss finish of lacquer also makes unnecessary any finishing coat of varnish. However, most manufacturers use both slip sheets and varnish in order to protect their finished work in shipment and to increase its durability.

Synthetic-varnish colors are used in preference to lacquer pastes by some shops. They withstand atmospheric conditions well and are more durable than either lacquer or air-dried oil colors. Baking is not necessary for either lacquer or synthetic-varnish colors.

Very attractive unbaked signs with a celluloid finish may be obtained by combining celluloid with the metal. The background of a design is first processed on metal with long oil colors. The design is then printed in reverse on. sheet celluloid cut to the same size as the metal. After printing, the celluloid sheets are laid on the metal, and the two materials are solidly joined by turning them back in a double fold along the edges. The signs are then stamped to form a beveled edge. This stretches the celluloid drumtight on the metal.

Porcelain- or vitreous-enamel signs differ from ordinary metal signs in that the pigments used are mixed with a compound called frit, the main ingredient of which is powdered glass or silicate. Porcelain-enameled signs are the most durable of all and, with ordinary care, will last for years.

Formerly, if white lettering was to appear on a blue background, the white was first applied over the whole surface, then fused to the metal by being baked for 3 minutes at a temperature of about 1600°F. Blue frit was then dusted over the whole surface, after which a brass stencil was placed on it and the frit in the open spaces was removed with a rather stiff brush, leaving the white enameled letters or design uncovered. The metal was then given a final baking. This method was naturally rather slow and expensive.

The recent development of a compound which can be applied by the screen process has made vitreous enameling much faster and cheaper and, at the same time, made possible the use of intricate patterns and color effects. It has also made possible the use of 60- to 85-line half-tone screens.

Before applying vitreous-enamel colors, the metal should be thoroughly cleaned with naphtha and then given gripping and priming coats by dipping or spraying, followed by baking. All colors of the design are processed before fusing, but each color must be thoroughly dry before the next color is stenciled. ' The vitreous-enamel, colors are usually fused in special electric furnaces by heating to over 1600°F. for 2 to 3 minutes.

Because of the rough usage to which screens are subjected in processing metal, they are usually made of triple-X silk of No. 12 to No. 20 mesh. Wire screens are much more durable and with proper care will last for thousands of impressions.

WOOD

For printing on wood, the same kinds of paints, lacquers, and methods are used that are employed on paper or cardboard.

Because of their porous nature, most woods consume a large quantity of paint; hence, the first or priming coat should be mixed with an oil varnish, which seals the pores of the wood. If the work is to be done on wood that has been previously stained or primed, further preparation is obviously unnecessary.

When printing on raw wood, it is usually advisable to give the surface a vigorous sanding before the priming coat is applied.

Owing to the thickness of wood, it requires the same build-up or make-ready that is used when printing on glass. By building up the areas surrounding the wood, the squeegee is prevented from jumping the edge of the wood and damaging the silk where it comes in contact with the sharp edge of the material being printed.

In many cases it may be necessary to print on cabinets, drawers, etc., already assembled. No very exact means of registering can be described here, for the make-ready most suitable in each case will be governed by the shape and size of the units to be stenciled. The ingenuity of the operator will come into play in devising ways and means of adjusting the make-ready to the job.

The finished work may be varnished by spray gun, screen stencil, or hand application.

If the primer or background color does not have to be applied to the very edge of the wood, this coat may be applied by means of a stencil. If an over-all coat is required, the color should be sprayed on. If the paint is to be applied by hand or by spray gun, it should first be strained through cheesecloth or a fine metal strainer, to remove all lumps or solid particles.

CHAPTER V

STENCIL MAKING METHODS

THE PRINCIPAL TYPES COMPARED

The stencils commonly employed in screen printing are of five principal kinds: block-out stencils, resist stencils, paper stencils, film stencils, and photographic stencils. There are also the mimeographic method and numerous variations of the five principal methods which, because of their decided limitations, have never become commercially practicable.

For all-round usefulness, the film stencils are considered the most practicable, but occasions arise where other kinds of stencils may be advantageously combined with film stencils. In still other cases film stencils may not be practicable at all. Therefore, if one wishes to be a skilled screen craftsman, it is not enough for him to become expert in the use of but one method; he must have a working knowledge of them all.

Block-out.—The block-out methods are suitable for large signs, banners, 24-sheet posters, theatrical posters, rough outdoor signs, and other work containing large simple masses where extreme sharpness of line is not essential. Whenever the areas to be covered are large enough to permit free movement of the arm, as in actual painting, the making of block-out stencils is rather easy; but when small lettering or other fine detail is required, it becomes very tedious. There have been cases where lettering only $\frac{1}{8}$ inch high has been made by this method, but such instances are to be considered as stunts, to be attempted only by expert workers.

Resist.—Resist stencils were considered the best allround mediums for screen work prior to the introduction of film stencils. Resist stencils are practicable when outline work plays an important part in the design. Hence, they are suitable for lettering, contour drawings, graphs, and maps, as well as other work of a large, simple character.

A resist stencil does not completely eliminate the mesh marks, which are the bête noire of screen reproduction, raggedness of line still being characteristic of this method. Another limitation is the prevalence of pinholes which develop in this type of stencil.

Paper.—For quantities not exceeding 500 prints, and designs involving simple masses of color, such as large signs, banners and 24-sheet posters, paper stencils are more economical than other kinds. In sharpness and clearness of line, they compare favorably with the very best work done by other methods. The cheapness of paper stencils and the small amount of preparation necessary, make them ideal for printing limited quantities of simple designs.

Owing to their thickness, paper stencils leave a heavier deposit of color than film, photo, or block-out stencils; but, since paper stencils are feasible for short runs only, the difference in paint consumption is comparatively unimportant.

Shellac and Lacquer Film.—The shellac stencil film, which came on the market in 1930, and the lacquer film, which came on the market two years later, have practically revolutionized screen printing. Both types of film stencils are cut in exactly the same way. They differ only in the manner in which they are made to adhere to the silk, a hot iron being used for shellac film, and a specially prepared lacquer thinner being used for lacquer film.

The use of film stencils definitely eliminates the raggedness of line which characterizes the block-out and resist methods. Prints made from film stencils closely simulate letterpress or lithographic printing, so far as sharpness is concerned. The film methods are therefore particularly well suited for work requiring clean, sharp lines, or work involving fine, lacy detail, such as delicate lettering and designs. The stencils are very durable, lasting for thousands of impressions.

Photo.—Photo stencils are made in somewhat the same way that negatives are made for the photo-offset and photo-gelatin printing processes. All of them make use of photographic principles which have been known since 1852. The beautiful carbon prints which are so much admired in photographic exhibitions are also made by much the same general method.

Up to the present time, but little use has been made of photo stencils in screen printing, although some of the earliest stencils were made by this method. There are many reasons why stencils of this type have not become popular, the principal ones being that methods have not been sufficiently developed and simplified to make them easy, sure, and foolproof. The various methods employed have been kept more or less secret by those who knew them and the average operator has not had either the knowledge or the skill to use them successfully. Furthermore, most screen operators have considered that photo stencils, being made by photographic or semimechanical methods, did not harmonize with a hand process and hence had no place in screen work. Consequently, they have not tried to explore the possibilities of the photo stencil.

There is a growing demand, however, for a practicable photo-stencil method, and it is possible that this demand will stimulate development. In fact, new materials for making photo stencils have recently come into the market which are intended to make the work easier and simpler. Should they prove successful, their use may open new vistas for screen work. So far, however, not enough time has elapsed for them to be thoroughly tested.

Photo stencils are ideal for reproducing the very fine, delicate work which is too difficult to handle by any of the other methods, or wherever photographic accuracy is required. Only by the photo stencil can very small lettering and fine pen drawings be reproduced in a way that does justice to the original. Photo stencils are also used for printing instructions on the back of displays; for printing price tags, textiles, decorations on machinery, on furniture and toys, on metal and glass novelties, etc. Even halftones and Ben Day tints may be reproduced, making possible new art treatments and color effects. See Fig. 64.



FIG. 55.—Crude pencil and ink sketch and the reproduction which was made from it—showing how the work may be "cleaned up" when making the stencils. This achieves a saving in the cost of the original art work.

Paradoxically, producing prints which are absolutely faithful to the original is both a virtue and a fault, because, in order to get a perfect reproduction, it is, of course, first necessary to have a perfect original. By any of the other methods, a faulty original may be cleaned up and otherwise improved upon when making the stencil. The use of photo stencils imposes other limitations, in that the gelatin used in preparing the stencils tends to shrink the silk and make it difficult to secure proper registration, especially in multi-color work.

Photo stencils are in some cases more costly and in many cases cheaper to prepare than other kinds, depending upon the nature of the job and how the work is planned.

BLOCK-OUT STENCILS

The block-out stencil is made by blocking out parts of the open mesh with glue, lacquer, collodion, shellac, varnish, or one of the special screen fillers. Regardless of the blocking-out medium used, the preparation of the stencil is much the same. In each case the filler is applied with a brush to the nonprinting areas, so as to leave the mesh of the silk open wherever the paint is to flow through.

Let us assume that the letter O is to be printed with black paint on a white ground from a glue block-out stencil. The first step is to prepare the original copy, which should be made actual size in pencil, ink, or paint.

The printing frame is set in the hinges and the original drawing is fastened on the base in the desired position under the screen. The frame is then lowered on to the base.

The transparency of the silk makes it easy to trace on it the outlines of the letter with pencil or India ink. After the letter has been traced on the silk, the frame should be lifted slightly so that the screen does not come in contact with the original drawing; or, the pins may be removed from the hinges holding the frame to the base so that the screen may be placed on a drawing table. A piece of white cardboard placed under the silk will make the painted areas contrast with the unpainted areas. The next step is to charge a lettering or show-card brush fully with the glue filler, and then to paint around the tracing. Dark anilin dye or water color may be added to the glue so as to show up better when applied to the silk. When the glue is dry (drying may be

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hastened by fanning), paint will not penetrate the areas thus blocked out.

While the original is still fastened in position, the registry guides should be nailed down; the original drawing is then removed.

Now all is ready to pour the paint on the screen, and begin printing.

Glue block-out stencils break down more quickly than others; hence, it is necessary to watch constantly for the development of pinholes in them. Pinholes should be filled or touched up with lacquer, shellac, or glue, as soon as discovered.

The shellac, lacquer, and collodion methods differ from the glue method in the following way: When using lacquer or shellac, it is not necessary to trace the design on the silk with pencil or ink. Instead, the whole surface of the silk should be given a very thin coat of glue, mixed in approximately the proportion of 1 part glue to 5 parts water. The glue acts as a transparent sizing of the silk mesh and minimizes the ragged-edged effect characteristic of the glue method. When the glue is dry, the blocking-out medium may then be painted on the silk around the outline of the original copy.

After the blocking-out medium is dry, glue should be removed from the areas which the paint is to penetrate, by rubbing an absorbent cloth, moistened with water, over the surface of the silk. Under no circumstances should the damp cloth be applied to the underside of the silk, as to do so would loosen the glue foundation on which the filler is painted and not only would the glue foundation be washed off, but the filler would come off with it. During this operation, the screen must be held in a perfectly horizontal position. If it is held at an angle while the glue is being removed, pressure on the cloth may cause water to seep through the painted edges of the design and break up the sharpness of line. Besides giving the silk a smoother working surface on which to apply the blocking-out medium, the glue sizing serves other purposes. It makes the matter of working on top of the original drawing a much cleaner procedure, as the thin coating of glue prevents the filler from flowing through to damage the original. The glue sizing also helps produce sharper prints by filling the mesh of the silk and giving a cleaner, unbroken line.

After use, stencils made by the block-out methods may be removed by washing the top and bottom of the silk with warm water. If lacquer, shellac, or other filler has been employed, soaking the silk from the underside will loosen the glue foundation so that the block-out medium will float off, leaving the screen clean.

THE SINGLE-SCREEN STENCILS

This method is sometimes called the Selectasine or elimination method.



FIG. 56.—Poster printed in 18 colors from 1 screen, employing the elimination method.

After the original has been placed on the printing base and registered in the guides, the hinged frame is lowered. Then, a thin outline tracing in India ink of all the detail for each color in the design is made on the silk.

To illustrate the correct sequence of the steps to be taken, let us assume that the design consists of four circles to be printed in red, yellow, blue, and green, respectively.

A block-out stencil should be made, leaving all of the circles open. Now the sequence of colors must be decided. There is no definite rule for this in printing with stencils of the single-screen type, since the decision in each case depends upon the nature of the job. As a general rule, it is best to print the lighter colors first. If, however, some fine lettering or other detail must appear in a light color on a dark ground, it may be advisable to print this color last. Again, if the darkest color occupies a large area while the lightest color takes up but a very small space, it may be advisable to run the light color last, in order to save paint. In the present instance, let us decide the sequence arbitrarily as red, yellow, blue, and green.

In the first printing, all four circles will appear in red. After this, the circle in the screen corresponding to the red in the design should be filled in with lacquer, shellac, or other filler, the three remaining circles being left open. The stencil is now ready for the second printing, which is to be in yellow. After this color has been printed, the same filler should be used again, this time to eliminate the area that will remain yellow in the finished work. The same procedure should be followed in preparing the stencil for the next color. When the last color is run, three of the four circles will have been completely blocked out.

From the repeated printing of one color over another which this process necessitates, the prints carry a very heavy deposit of paint, causing each color to stand out in relief, with an effect of embossing. Formerly, this effect was much admired by some adherents of screen printing. The present tendency is to make prints as smooth and as thinly coated as possible.

Although this method is now used very little because of the excessive amount of paint consumed, it has, nevertheless, certain advantages. Accurate registration is assisted because the same screen and make-ready are used for printing all the colors. It is a quick way to make stencils, since it requires but little time to block out or paint in a limited area on the stencil and thus prepare it for use for successive colors. It is especially suitable whenever a raised or embossed effect is desired in the finished work.

RESIST STENCILS

In making resist stencils, the operator may take advantage of the fact that certain mediums resist the action of some solvents but are easily soluble in others. Lithographers' tusche is by far the most popular resist medium, although tempera water-color preparation, japan color, and asphaltum are also used. Tusche is a black liquid resembling artists' waterproof drawing ink, but is slightly greasy.

Various techniques have been devised for making resist stencils, many of which have proved impractical or inefficient. The methods described here will be only those which have been found to be the most satisfactory.

In making a resist stencil, the original is centered on the base under the screen and the guides nailed in position as was done with block-out stencils. The design is then traced on the silk with India ink or pencil.

Upon completion of the tracing, a sizing is applied to the underside of the silk with a sponge. The sizing is prepared by mixing about a tablespoonful of ordinary cornstarch with a glass of cold water. Drying usually takes about 15 minutes.

The sizing serves to clog the mesh temporarily, thus giving the silk a smooth working surface; it prevents the tusche from seeping through the silk and damaging the original; it whitens the silk, improving the visibility of the work by heightening the contrast between the silk and the tusche; it produces a sharper print.

In this method, the open silk is not permanently blocked out in parts, as is done in the block-out method. Instead, the master sketch is actually copied on the upper surface of the silk, the operator using a lettering brush charged with

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tusche exactly as if he were making a black-and-white drawing.

Before tusche is used, it should always be stirred thoroughly. If the solution becomes too thick, it can be thinned with turpentine or water. When the design is completely painted in, the tusche should be allowed to dry for about 30 minutes, or it may smear when the next step is taken.

A coat of cold liquid glue is now scraped over the whole surface of the silk with the edge of a piece of stiff cardboard. Unless the first coat of glue is a heavy one, a second coat must be applied, in order to guard against the appearance of pinholes. The glue used for this purpose should consist of 50 per cent glue and 50 per cent water.

In the shellac or lacquer block-out methods, glue is used merely to size the silk, but in this instance it is used as a filler. When the glue is dry, the mesh is ready to be opened in the areas painted with tusche. This is done by saturating a cloth with turpentine, kerosene, naphtha, or benzene, and rubbing it over the under surface of the screen. The solvent melts the tusche and removes both it and the cornstarch size, but does not affect the glue filler which covers the areas surrounding the design.

The stencil must be thoroughly dried by rubbing both sides of it with plenty of dry cloths. If any edges of the stencil are slightly ragged, this defect can be remedied by rubbing gently along them with a steel brush commonly used for brushing suede. In brushing these edges, a brisk application should be avoided because it may cause the formation of numerous pinholes.

On rainy days, the humidity may unduly retard the drying of the glue. The drying may be hastened by the use of an electric fan, but an electric heater serves best for this purpose as it not only quickens the drying but also makes the glue harder.

If desired, either lacquer or shellac may be used in place of glue for a filler, the method of application being the same. If glue is used, it is easy to wash the stencil out of the silk after the job is completed, the mere application of water being sufficient to dissolve the glue and thus clear the silk. Lacquer and shellac stencils are more expensive, and more difficult to remove. On the other hand, pinholes are much less likely to develop in them than in glue stencils. Denatured alcohol or paint remover may be used to wash out stencils made of shellac, and either lacquer thinner or acetone is used to wash out stencils made of lacquer.

The tusche-glue method has a tendency to shrink the This is of little consequence in one-color jobs, but it silk. must be taken into consideration in multicolor work. Contraction of the glue causes a corresponding shrinkage of the stencil, which may make it somewhat difficult to secure proper registration of the various colors. One way to overcome this difficulty is by the use of a key stencil; that is, an outline of the design. The color selected for making the key stencil should be the one which will serve best to tie all of the colors together: in most cases, it is the black. After the key stencil is made, one impression is taken from it to serve as the master impression in making stencils for the remaining colors within the boundaries of the key outline. Comparison of the key impression with the original will show the amount of shrinkage, so that any necessary corrections may be made in the stencils for the successive colors. The stencils for all the other colors to be used must correspond with the key impression. In the regular printing operation, the key stencil is usually run last.

Although the screen process lends itself best to flat, poster treatment, stippled effects and broken tones, or dry-brush effects may be obtained by means of tusche. Dry-brush effects are obtained by charging the brush with so little tusche that the brush is almost dry when applied to the silk. In other words, the tusche is applied to the silk in the same way that artists make dry-brush drawings with ink. Soft tusche crayon in stick form, such as is



FIG. 57.—This example shows the use of dry-brush treatment on the central figure to produce a novel, modern effect. Both tusche resist and film stencils were used on this poster.



FIG. 58.—The figure in this illustration was printed with tusche stencils. A film stencil was used for the lettering.

used by lithographers, may also be employed for this purpose.

If correctly prepared, the tusche will wash out of the painted and partly painted areas.

For most resist stencils, No. 12 silk will be found satisfactory. For special dry-brush or crayon effects, however, it is best to use Nos. 14 to 18.

FILM STENCILS

Both the lacquer and shellac types of stencil film are composed of two layers. The bottom layer consists of a thin sheet of glassine paper, which acts as a backing or support for the thin layer of film. Owing to the transparency of the film, no transfer tracing is necessary.

In the preparation of the stencil, a piece of film, cut to the proper size, is first placed over the original drawing, film side up, and fastened in place with Scotch tape. It is then properly centered under the printing frame, and the guides are fastened in position on the base. When this has been done, the original drawing is removed to the work table for the cutting operation. It is advisable to place a thin sheet of celluloid between the film and the original. In making original drawings, artists sometimes permit tempera color to become thick and lumpy, making it difficult for the operator to cut a clean, straight line, when the stencil blade strikes these bumps. Placing celluloid over the original overcomes this difficulty and gives the operator a smooth working surface.

The outline of the original is incised with a film-stencil knife, which differs from the one used in cutting paper stencils both in size and in the shape of the blade. It may seem difficult at first to cut through the upper surface of the film without also cutting through the backing, but with a few hours' practice one learns to apply just the right amount of pressure to the knife.

A ruler may be employed in cutting straight lines, and an ordinary compass may be used for cutting circles, if the lead

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is removed and a blade inserted in its place. When horizontal strokes of letters are to be cut, a metal T square, or a steel rule, may be laid across the drawing to guide the knife. A long iron bar, about 1 inch square, is also valuable for this work, because its weight prevents it from shifting position.



FIG. 59.—The oval panel in this poster shows how very fine pen lines may be reproduced by knife-cut film stencils.

Thin, straight, parallel lines may be cut in one operation by sharpening the points of a ruling pen and then adjusting them to the width of the required line. When the ruling pen is drawn across the film, the two lines will be cut at one stroke. This method is not always practicable in tracing lettering because of the varying thickness of the strokes.

For making long strokes, a free-swinging forearm movement is used, short strokes being made with a movement of the wrist or fingers. In cutting fine, curved detail, the knife is held lightly between the thumb and middle finger, STENCIL MAKING METHODS

in an almost vertical position. The blade is then given a slight twisting or rotary movement. See Fig. 60A.

It will be readily seen that the making of a knife-cut stencil requires cutting on both sides of a line. This makes the difficulty of stencil cutting greater in proportion to the

FIG. 60A.—Position of knife and fingers during cutting operation.



FIG. 60B.—Stripping of the film.

smallness of the work, the most difficult designs being those which include crosshatched lines, or fine maplike contours.

When cutting the film, it is not necessary to avoid overcutting intersecting lines. That is to say, when cutting a rectangle, it is not necessary to cut exactly to the corners of the area. If any overcuts are made, they will automatically be sealed when the stencil is affixed to the silk. The operator may find that the color of the stencil film alters the appearance of certain colors on the original. If a dark-blue area is surrounded by black, the whole area may look black through the film. This may be overcome by outlining the blue area on the original drawing with a fine pencil line. Although the pencil outline may not be easily visible on the original, it will show up clearly through the film.

If crosshatched lines appear on the drawing, the easiest way to cut a film stencil for them is as follows: Cut and strip all the lines in one direction first. It will be seen that the lines in this first series may be stripped in one piece; but when the crosslines have been cut, they will have to be stripped in a number of short pieces, owing to the fact that the lines will be broken wherever the first series has already been stripped.

If extreme sharpness in the crosshatching is not necessary, the easiest method of handling it is to paint the crosshatching on the screen with tusche. Since tusche is applied like ink, the lines may be painted on the screen as quickly and easily as they were made on the original.

Stripping.—As soon as the design is traced, the film is ready for stripping. This is done by inserting the point of the knife under one corner of the cut portion, and then carefully peeling off the part of the film that is within the traced area. In other words, stripping is done within the boundaries of the design. After the stripping operation, the operator will find that the centers are still held securely in place by the glassine backing. See Fig. 60B.

Upon completion of the stripping, the original drawing, with the film still attached to it, is placed in the guides on the base; the frame is hinged and lowered so as to bring the film and the underside of the silk into contact. Wherever large open areas occur in the stencil, slits should be cut in the backing paper, to permit air to escape during the adhering. The stencil is now ready to be affixed to the screen. Adhering Lacquer-film Stencils.—Adhesion of the stencil to the screen is accomplished by the use of lacquer thinner especially prepared for the purpose, and usually purchased in combination with the film. Since the thinner must be neither too weak nor too strong, it is best to use a product specially prepared, for this purpose.

First, a soft cloth is dampened with thinner and applied to the upper side of the silk, so that the thinner will seep through and reach the film. Follow this up quickly with a dry cloth which has been rolled up in the form of a pad. The dry rag is used to complete the adhesion of those areas of film which have been rubbed lightly with the damp cloth. Work on only a part of the stencil at a time, so as to avoid giving the thinner a chance to attack the film for more than a moment. Care must be taken not to apply too much thinner to the cloth, or it may dissolve the film.

If the adhering has been done properly, the film, with its backing paper still in place, is now permanently attached to the silk. The frame is lifted and the original drawing is removed. After waiting for several minutes to permit complete evaporation of the thinner, the operator gently peels the backing proper from the stencil.

If it is now found that any part of the film has not adhered to the silk, the damp cloth is again lightly applied, as before. It is not necessary to rub over the whole stencil when fixing unattached spots. If this second rubdown seems necessary, a piece of glassine or wax paper should be placed underneath the film. This is to protect the edges of the stencil, because the application of thinner directly over an absorbent surface such as cardboard may dissolve the edges.

If only enough film is used to cover the design, it will be necessary, of course, to block out the surface all around the stencil and up to the edge of the frame, in order to make the stencil leakproof. This blocking out may be done with lacquer, shellac, or paper mask. If lacquer or shellac is used as a masking medium, apply it by spreading with the sharp edge of a piece of hard cardboard.

The screen is then taped around the edges, and all is ready for the paint to be poured on for the printing operation.

Lacquer film may be removed from the screen by liberally applying lacquer thinner, until the film is completely dissolved, and the mesh of the silk is left clear. Because of its volatile nature, it is advisable to apply the thinner as rapidly as possible, to only a small area at a time, and to dry it immediately.

Adhering Shellac-film Stencils.—If the stencil is made from shellac film, the original is first placed in the guides on the printing base, as for lacquer-film stencils. The screen is then lowered and a hot iron is touched to the screen in several places to adhere the film slightly to the silk. The frame is then raised, and a piece of smooth cardboard is slipped under the original on the printing base so as to bring stencil and screen into firmer contact when the frame is again lowered.

When the frame is lowered, the hot iron is again applied to the screen in a continuous movement from the center outward to the edges. Do not let the iron become too hot. A piece of wrapping paper should be placed between the iron and the silk. Lift the paper frequently to see whether the stencil is adhering properly. The parts where the film has adhered will look darker in color than the parts where it has not.

When the film has completely adhered, let it cool for a few minutes. Then lift the frame and remove the original drawing and backing paper from the stencil. To do this, take hold of one corner of the backing paper and pull it slowly away from the stencil. If any part of the stencil has not adhered properly, let the backing paper fall back in place, lowert he screen again, and give the loose parts another ironing.

When the stencil is properly adhered, the space around it is masked out, as in the case of lacquer-film stencils. To remove the stencil after completion of the run, first place some old newspapers underneath the screen, and then over it lay a heavy woolen cloth, saturated with denatured alcohol or paint remover. Allow to soak for 15 or 20 minutes, and then rub the cloth briskly over the screen, thus causing the stencil to come loose from the silk.

Screens for Film Stencils.—Either organdy or silk may be used as the screen for film stencils. For ordinary work, organdy will give satisfactory results if the printing is done correctly, but for greater durability No. 10 silk bolting cloth is recommended.

FILM CUTTING EXERCISES

The following exercises will be helpful in developing ease and facility in cutting and stripping film.

1. On a piece of smooth drawing board or cardboard about 10 by 14 inches, draw in pencil outline several profiles or silhouettes of a head, about 2 inches high.

Then, with Scotch tape, fasten a piece of film to the cardboard, and trace the silhouettes in film, as shown in the illustration. Try to make the features and proportions as near normal as possible, without any effort to make a portrait of any particular person.

Start at the crown of the head, holding the knife lightly between the fingers, and, with a twisting or rotary movement, trace the face and neck. Do not stop or lift the knife during the process. Start again at the crown of the head, and thence trace the back of the head, continuing the line until it meets the first one. Then, insert the point of the blade under the film in a convenient corner, and try to pull off the cut film in one piece.

Continue the exercise, making the heads smaller and smaller as proficiency increases.

2. Hold the knife in a perpendicular position and cut, with one continuous movement, each side of the wavy line shown. Then cut the film across both ends of the line and try to peel off the entire spiral in one piece.

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It will be found that these two exercises develop in the operator a certain ease in manipulating the knife. He also learns to strip the film with as few operations as



FIG. 61.—Exercise 1.

possible, thus saving time and reducing the danger of making nicks and broken lines.

Slight variations in contour are not conspicuous in these exercises. The next exercise, however, calls for accuracy in cutting shapes, contours, and boundaries.

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3. Cut series of ovals or O's as shown in the illustration, making them as smooth and symmetrical as possible. Cut each complete contour in two movements, and strip in one piece, in the same manner as in the previous exercises.

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FIG. 62.—Exercise 2.

PAPER STENCILS

Various kinds of paper and several methods of preparation are employed in making paper stencils. In some cases,

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the stencils are cut from the plain paper and in others the paper is treated or coated with shellac, lacquer, glue, etc., before use.



FIG. 63.—Exercise 3.

Perhaps the most popular stock for stencil making is the ordinary white sulphite bond or poster paper, such as sign painters use for making window streamers; but glassine paper, vellum tracing paper, kraft paper, and various other stocks have their distinct advantages for certain types of work.

The popularity of poster paper is due to the fact that it is cheap and easily obtainable, and that it may be cut very easily and cleanly. Although this paper is not normally transparent enough for one to see the details of an original drawing through it distinctly, the paper may be made temporarily transparent by dampening it with turpentine.

Glassine paper has a natural complete transparency which makes it a convenient stencil material. Besides, it is somewhat impervious to the oils used in process paints. Glassine stencils, therefore, last longer than those made of poster paper.

Vellum tracing paper is sometimes used, because it has the transparent quality essential for stencil paper. This paper is especially treated, to make it tougher and more transparent than ordinary tracing paper.

Kraft paper is comparatively heavy, and stencils made with it deposit a thick coat of paint on the printing surface. This makes kraft-paper stencils especially suitable for work which should present a raised or embossed effect, such as is often desired on metal signs. Owing to the opacity of kraft paper, the design cannot be traced on it from the original drawing. Accordingly, when kraft paper is used, the design must be carefully sketched in pencil directly on the paper which is to serve as the stencil.

Poster-paper Stencils.—Sign shops are frequently required to make large inexpensive signs and banners for very quick delivery. Original drawings made to size are not often supplied by the customer for this class of work; therefore the lettering or design is sketched carefully in outline on poster paper with a pencil and the stencil is cut along the pencil lines. Although this method is most suitable for one-color work, stencils for designs involving two or more colors may successfully be prepared in this manner, unless the design to be reproduced includes very intricate detail. The pencil outline drawing is prepared on a sheet of stencil paper about the same size as the screen to be used, so that it will not be necessary to block out the space around the stencil. This is true of all paper stencils.

After the pencil sketch is finished, the paper is laid on the printing base in proper position, and fastened down with Scotch tape. The stencil is then cut with a paper-cutting knife. It is not necessary to take any special precautions about overcutting lines at their intersections, because overcuts are automatically sealed, when the stencil is adhered to the silk.

After the pencil outlines have been cut, the Scotch tape is removed without disturbing the cut paper. The loose pieces are not removed, but are left in their original positions. The frame is now hinged, and laid directly over the stencil. Paint is next poured on the center of the screen, and the squeegee is passed over the screen with an even pressure, moving from the center outward to the ends and sides of the frame. This is done in order to prevent air from accumulating between the silk and the stencil, where it might form undesirable air bells, or pockets, which would cause imperfections in the printing.

The paint used in this method is heavier than that used in other methods, because it must also act as an adhesive. As the squeegee forces this heavy paint through the silk, its normal tacky consistency makes the entire stencil adhere to the under surface of the screen. The printing frame is now lifted, in order that the cut paper which forms the lettering or design may be stripped or peeled from the silk. In doing this, the operator must be specially careful not to disturb the positions of the center pieces. While the frame is lifted, it is advisable to secure the edges of the paper to the silk with Scotch tape or gum paper.

Ordinarily, the adhesive quality of the paint will be sufficient to hold in place the main body of the stencil, as well as the centers. In runs exceeding 100 impressions, however, or in multicolor work, where exact registration is essential, it is helpful to secure the centers in place in the following manner:

As soon as the cutting has been completed, each center that is to remain is numbered with a pencil. After the frame is hinged and placed in direct contact with the paper, ready for the paint, a little lacquer or glue is applied to the top of the silk directly over each marked centerpiece. This lacquer or glue will seep through the silk to the paper, and in a few minutes the centers will be much more securely fastened to the screen than if they were attached only by the adhesive quality of the paint.

Working Over an Original Drawing.—Of course, if an original drawing is furnished, it is unnecessary for the operator to make a sketch from which to cut the stencil. In this case, he must fasten the stencil paper to the original with Scotch tape, before proceeding to cut. One soon acquires the knack of applying the right amount of pressure to cut through the stencil paper without injuring the drawing. Whenever special care must be taken of the original, however, it is better not to cut the stencil directly over it, but to make a key tracing to be used as a duplicate of the original.

The tracing is then carefully mounted on a piece of white cardboard of the same size as the stock to be printed. The original is used for reference purposes only; the stencil is then cut directly from the duplicate.

After the cardboard, with the cut stencil affixed, has been transferred from the work table to the printing base and placed in position in the guides, the Scotch tape is removed, the frame is lowered, and paint is squeegeed through the silk, as previously described. Even when the stencil is cut from the master sketch, rather than from a tracing of it, it will be found that, when paint is squeegeed through the silk, the original will not be marred. The cut pieces of paper, being still in their original position, will prevent paint from flowing through to the master sketch.

When printing from paper stencils, it is essential to mix the paint properly before starting the printing so that it will have the required consistency and drying quality. Changing the paint during squeegeeing is an awkward operation and frequently causes trouble.

If the paint has a tendency to dry too fast, so that it clogs the mesh of the silk, it will be necessary to remove it from the screen. The delay thus caused may make the silk clog even more and may necessitate a general wash with turpentine. This is to be avoided if possible. If the paper is soaked too much in the operation, pockets and wrinkles form in the stencil and precision of register is generally destroyed.

If it is found that a small air pocket is causing a spot to print imperfectly, this can be remedied by making a slight incision in the paper. Upon the escape of the air, the cut in the paper will close of itself.

Use of a Backing Sheet.—When making very large paper stencils, the operator will find that the methods outlined above serve the purpose very well, because the parts are comparatively large and easy to handle. However, some operators find it necessary or desirable at times to employ paper stencils for work involving moderately fine detail. In these cases, it is much more difficult to detect or prevent any slight shift of the loose portions during the operations of cutting, adhering, and printing.

To forestall difficulties of this sort, the stencil paper may be temporarily attached to a backing sheet. This may consist of heavy wrapping paper or lightweight cardboard. However, by the use of a suitable adhesive, such as very this rubber cement or turpentine-dammar varnish, the stencil paper may even be attached to the original drawing, without injury to the latter. Whatever preparation is used, it must possess only a very slight adhesive quality, barely enough to hold the centers in place during the cutting operations, so that, when the stencil paper is pulled away from the backing sheet, there will be no interference with proper adhesion of the stencil to the screen. Special adhesives may be purchased to make the stencil paper adhere to the backing sheet. Soft soap, or Canada balsam dissolved in turpentine may also be used. Still another satisfactory temporary adhesive may be made by warming equal parts of beeswax, kerosene, and linseed oil in a double boiler.

After the adhesive is applied to the back of the stencil paper, it is placed on the backing surface, and all wrinkles or air bells are smoothed out with a squeegee. The stencil is then cut; next, the pieces of cut paper which cover the parts of the design to be left open are peeled or stripped from the backing sheet, as is done in making film stencils.

The stencil is brought into contact with the screen in the usual way, and attached to it by daubing lacquer or shellac on top of the silk directly over the center pieces and other closed parts. The paint is then squeegeed over the screen to effect the adhering; the frame is raised, and the stencil comes away from the backing sheet or the original.

Plain-paper stencils are removed after the completion of the run merely by tearing the paper off the screen. If shellac or lacquer has been daubed on the silk to make the stencil adhere better, the spots may be removed with paint remover or lacquer thinner. The screen is cleaned in the same way as in other methods, after which it is again ready for use.

Screens for Paper Stencils.—Either silk or organdy may be used with paper stencils. When using silk, it is advisable to select a No. 8 or No. 10 mesh so as to avoid any possibility of the silk clogging during the squeegeeing operation.

Shellacked-paper Stencils.—Shellac-coated paper stencils are more durable than plain-paper stencils and adhere much more firmly to the screen. For simple jobs they may be used in place of shellac-film stencils, to which they are closely related. Adhering the centers of shellacked-paper stencils to the screen is a rather tedious operation. Consequently, their use is confined chiefly to work of a very broad nature, unless the stencils are attached to a backing sheet.

If the original copy is to be drawn or traced directly on the stencil paper, this should be done on a good quality of vellum tracing paper before the paper is coated. Then the tracing is pinned face up to any smooth, level surface and is given two thin even coats of orange shellac. A few drops of castor oil should be added to this shellac to make the coating pliable and easy to cut. Castor oil greatly retards the drying of the shellac; hence, if more than a trace of it is used, the shellac may take several hours to dry. The shellac may be applied with either brush or spray gun. Only one side of the paper is to be coated and the first coat should be given time to dry before the second coat is applied.

These stencils are cut in very much the same way as plain-paper stencils, with the following exceptions. In the case of the uncoated-paper stencils, all parts of the paper which were cut were left in place until after the stencil had been adhered to the screen. Before adhering shellaccoated-paper stencils to the screen, the cut parts are removed from the stencil and carefully laid aside with the centers for further use. The centers are numbered and their positions are designated by corresponding numbers on the stencil. This procedure is essential if the design contains many small centers, because these must be adhered to the screen after the main part of the stencil is attached.

To adhere, lay a sheet of smooth cardboard on the printing base, then place the stencil in proper position under the screen and lower the frame. If the stencil is still fastened to the original drawing, the tip of a hot iron is touched lightly to several parts of the screen, to make the stencil adhere somewhat to the silk, and thus insure the safe removal of the original.

After the original is removed, the iron is moved rapidly over the screen, working from the center toward the sides. The iron should not be permitted to become too hot; it should be just hot enough to make the shellac stick to the silk, but not so hot as to make the shellac stick to the iron. A piece of wrapping paper should be kept between the iron and the screen. To make sure that all parts adhere properly, the operator should follow the iron as it is moved over the screen, pressing the ironed surface with a soft, lintless cloth held in his left hand.

Now to adhere the centers: turn the frame over and temporarily place on the stencil those parts that were cut out and saved. This makes it easy to determine exactly the correct positions of the centers. Without moving the frame, the operator adheres the centers in position by lightly touching them with the point of the iron. The frame is then turned back and the centers are finally ironed on. The stencil is ready for use when the cut parts are removed.

After completion of the printing, the stencil may be removed by the liberal use of denatured alcohol or paint remover.

Lacquered-paper Stencils.—Lacquered-paper stencils are prepared in the same way as those made with shellac, except that lacquer, instead of shellac, is applied to the tracing paper.

Adhesion to the screen is accomplished in the same way as for shellacked-paper stencils except that a cloth, moistened with lacquer thinner, should be rubbed over the screen, as in the case of lacquer film.

After use, lacquer thinner is used to remove the stencil from the screen.

Glue-paper Stencils.—A thin paper, gummed on one side, is used in making glue-paper stencils. This gummed paper may be obtained from paper firms or from screensupply houses.

The stencils are adhered by first moistening the silk with a damp rag; then lowering the screen on the stencil; then by applying a hot iron over a water-dampened cloth spread

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on the screen, until the gummed paper adheres to the screen. These stencils are used chiefly when lacquer is to be the printing medium.

CELLULOID AND CELLOPHANE STENCILS

Celluloid stencils are cut in the same way as paper stencils. A fairly heavy sheet celluloid is employed, and the stencils are adhered with film cement or the following preparation:

| Sulphuric ether | 5 parts |
|------------------|---------|
| Acetone | 5 parts |
| Celluloid scraps | 2 parts |
| Camphor | 1 part |

The stencils may be removed from the silk with paint remover or acetone. A coarse-meshed silk should be used for the screen.

Celluloid stencils are extremely durable and may be used for thousands of impressions without noticeable wear. They are employed when a heavy deposit of paint is required. A serious objection to them is that they are very difficult to cut.

Stencils may also be made of cellophane, but the thinness of this material makes it difficult to apply the stencils to the screen without wrinkling. This difficulty may be overcome by attaching the cellophane to the original, over which a coating of very thin rubber cement or other adhesive has been applied. The cellophane is then given a coat of shellac and allowed to dry before the stencil is cut. It is adhered to the screen with a hot iron in the same way as shellac stencils.

MIMEOGRAPH STENCILS

Mimeograph stencils are sometimes used in the silk screen process to reproduce typewritten testimonials, sales letters, miscellaneous instructions, and announcements. In the dress industry this method is frequently used for circularizing descriptions of new models. Usually a fashion artist makes a sketch of a gown on the stencil with a stylus and the circular carries both the sketch and the typewritten description.

To make stencils of this type, the operator must get standard mimeograph sheets from a stationer. The stencil stylus or pencil must also be procured for copying signatures and making line drawings on the mimeograph sheet. The typist removes the ribbon from her typewriter, sees that the type is clean, inserts the mimeograph sheet in the typewriter, and proceeds to make a stencil from the original letter in the usual manner. Then the signature is copied on the stencil with the stylus. If an artist's drawing is to be reproduced with the typewritten matter, it must also be sketched with the stylus.

It is now necessary only to remove the backing paper from the mimeograph copy and register the stencil under the screen. The stencil is adhered to the silk in exactly the same way as plain-paper stencils; that is, the frame is lowered and paint is squeegeed through the screen. The tacky quality of the paint will make the stencil adhere to the silk.

These stencils are suitable for very short runs only. Best results are obtained when a dark color is printed on soft light-colored stock.

PHOTO STENCILS

Photo stencils are made possible by the fact that certain kinds of organic colloids (gelatin, albumen, glue, etc.), when impregnated with chromic salts (ammonium bichromate or potassium bichromate), become sensitive to light. To illustrate: Make a drawing on transparent celluloid with India ink. Lay the drawing on a sensitized gelatin film, and expose to the light. Wherever light penetrates the celluloid, the gelatin will become so hard that it cannot be dissolved in hot water. The parts of the gelatin which are



FIG. 64.—Half tone taken from a newspaper and printed with a photo stencil.

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shielded from the light by the opaque layer of ink will be unaffected and may be readily washed off with hot water.

Success in making photo stencils depends very largely upon care and the observance of fixed rules. Good results cannot be achieved if the operator merely guesses at the proportion of his chemicals or at the strength of the light. For this reason, daylight which is ever changing is not so satisfactory as artificial light for stencil-making purposes.

It is best first to make test exposures, with the light at various distances from the copy, keeping notes of the result



photo stencils.

FIG. 66.-Trade-mark printed with photo stencils.

of each exposure. When conditions for the ideal exposure have been ascertained, make an exposure table and follow it thereafter as closely as possible. Some deviations will be necessary because drawings which contain fairly coarse detail will require a longer exposure than those which contain fine lines or half-tone dots. Also, a drawing made on celluloid may require a shorter exposure than one which is made on tracing paper. But, even in such cases, the exposure table will be very useful as a yardstick for measuring comparative length of exposures.

Slight overexposure will usually not be harmful to work consisting of rather coarse detail; but, in reproducing very delicate lines, even a short overexposure may spoil the work. More care must also be exercised for work involving fine detail, when washing out the stencil.

One 300- or 400-watt light is sufficient when making exposures for small stencils. When the light must be moved back in order to illuminate large copy, it should be remembered that, when the distance from the light to the copy is doubled, the length of exposure necessary is quadrupled.

An evenly exposed print can be secured only when the light is evenly distributed over the whole surface of the copy. The rays of light should strike the copy at practically a right angle. Slanting beams of light will cast shadows from one side of the lines in the copy upon the opposite side, and light will creep under the copy, partially hardening the gelatin, so that it will not wash out properly.

Elaborate lighting equipment is not necessary but, of course, the more powerful the light, the shorter the exposure. The best results are obtained by the use of carbonarc lamps, such as photoengravers use, but they are too expensive for most screen-printing shops. Excellent results can be obtained from photo flood lamps, used with reflectors. These have a power rating of 650 to 1000 watts, and give 2 to 5 hours of service. Small studio arc lamps which give good results may be obtained at reasonable prices. Health lamps may also be used, provided the sunshine carbons are employed instead of the ultra-violet or infra-red carbons which are sold with the lamps.

Sensitized screens should be kept in a room that is completely dark and free from dust. Grease and dust are enemies of all photo stencils. The silk should be well washed before use to make sure that it is clean, and to preshrink it as much as possible.

Touching the sensitized gelatin with the fingers may cause pinholes. The sensitized surface is very tender when wet, therefore, the merest touch with the fingernail may be sufficient to damage the surface. No. 13 or No. 14 bolting cloth is best for all-round work; No. 12 can be used for most poster work; for most fine detail, Nos. 15 and 16 will be suitable. Organdy can be used instead of silk for ordinary commercial work, provided it is given four coats of gelatin. Its fragility renders it unsuitable for industrial work, where long service is required.

The screen should be stretched tight, without wrinkles, and the mesh of the fabric should be parallel to the sides of the frame. Bronze metal cloth is much more expensive than silk but, if photo stencils are used regularly, the extra cost of the metal cloth will be more than justified by the long service it will give.

Increasing the strength of the sensitizer will reduce the time required for exposure, but will not produce such good results as a weak sensitizer.

Gelatin is superior to glue as a stencil-making medium because it has "life" in it; that is, it may be slightly bent repeatedly without breaking. Even after being sensitized and hardened, gelatin retains a certain flexibility that is lacking in glue. Drying the gelatin in front of an electric heater, baking it, or drying it in the sun destroys this flexibility and makes the gelatin brittle, so that cracks are liable to form in it.

None but the very best grade of gelatin should be used, such as Nelson's No. 1. It may be obtained from drug or photographic supply houses. Sheet gelatin is preferred by most operators, although the pulverized variety is just as good, provided it is not adulterated.

In the direct method, the sensitizing solution may be added to the gelatin before it is applied to the silk, or it may be brushed on after the screen has been coated with gelatin.

Either ammonium or potassium bichromate may be used, although most formulas specify the latter, to which ammonia or soda carbonate is frequently added to make the solution less acid. These alkalies have the further effect of making it easier to remove the gelatin from the screen when the stencil is no longer needed. On the other hand, they render the gelatin more brittle, and thus less permanent. Many sensitizing formulas include a small amount of glycerin, the purpose of which is to make the gelatin more pliable.

Direct Method.—In making stencils by the direct method, the following recipe will provide sensitizer enough to cover about 6 square feet of silk.

| Gelatin | 1 | ounce |
|---|----------------|--------|
| Water | 10 | ounces |
| Soda carbonate, 10 grains, or ammonia (28 | \mathbf{per} | cent), |
| 10 drops | | |
| Potassium bichromate | 96 | grains |

This makes a sensitizer of about 2 per cent strength. Put cold water in the top of an enameled or graniteware double boiler (not aluminum or other metal); add the gelatin, and let it swell for 20 or 30 minutes. Partly fill the bottom part of the boiler with water and put on the stove to heat. When the water is quite hot, put on the top part of the boiler, containing the gelatin. Heat until it is completely dissolved, but do not let the gelatin come to a boil. Now pour in the bichromate, stirring with a wooden spoon or glass rod until it is dissolved. To render details of the future stencil more visible, tint the gelatin with a bit of anilin dye, or squeeze some of the paint from a tube of transparent water color into the gelatin, making sure that it completely dissolves. Apply the hot gelatin to the silk with a wide, soft brush, making sure first that the brush is thoroughly clean. Use horizontal brush strokes in coating one side of the silk, and vertical strokes for the other side. If the photo stencil is the only one on the frame-that is, if it is not to be combined with a hand-cut stencil—this first coat of gelatin should extend all the way out to the edge of the frame, even covering the nails, if they have not already been covered with gum tape.

Then stand the frame before an electric fan to dry. This should take 15 to 30 minutes. Meanwhile, the remainder of the gelatin in the boiler is cooling. This is well, because the second coat must be a thick one. As soon as the screen is dry, apply the second coat to both sides. Do not go over any surface a second time, as the brush might pick up some of the gelatin already on the silk.

If the solution gels too stiff, it should be warmed again slightly, before the second coat is applied, because the gelatin must not be applied to the silk in a lumpy condition.

Again let dry, and then give it a third coat. Coating may be done in a room which is lighted by a 15- or 25-watt bulb, provided the screen is held away from the source of the light. All later operations, however, must take place in a room lighted only by a ruby lamp or candle. The solution does not become fully light-sensitive until it is dry.

Exposure.—If a light box is used in making the exposure, the transparent copy to be photographed is attached to the undersurface of the screen with the drawing facing toward the silk. The copy can be temporarily adhered to the screen by smearing a bit of axle grease or vaseline all around the margin of the copy. This must be completely wiped off the screen before development takes place. Rubber cement may also be used, but it should not be placed over the face of the copy, because rubber cement, if thick or lumpy, is likely to photograph opaque.

Now place the screen, silk side down, on the glass top of the light box. Cover the upper surface of the screen with black paper, black velvet, or rubberized cloth such as photographers use, and smooth out all wrinkles. Weights must be placed on top of the silk, because sharp outlines will result only if the silk and copy are in absolutely close contact. Then make the exposure. The amount of time required will depend upon the power of the light, the distance from light to copy, and the transparency of the copy. Excellent results have been obtained from ink drawings on tissue paper by exposing the copy 13 inches from a 300-watt bulb, for 16 minutes.

If a light box is not available, exposure may be made in the following manner:

Select a piece of plate glass which is slightly larger than the stencil yet small enough to fit inside the frame. Ordinary glass is not suitable because it is seldom perfectly flat, especially in the larger sizes. Lay the glass on the table, elevating it on books or blocks of wood to a height equal to the thickness of the frame. Place over the glass a piece of black cloth, about as large as the frame, and smooth out all wrinkles.

Lay the screen, bottom side up, over the glass, so that the part which is to receive the stencil is centered directly over the glass. Place the transparent copy in the correct position on the screen, with the drawing facing toward the silk. Now lay on the drawing a piece of plate glass about the size of the frame. Inspect the setup with a weak light to make sure that screen and copy are in close contact. It is best to put some weights on the edge of the glass. Place a 300- or 400-watt light directly over the copy, and make the exposure.

Development.—Development should take place in water at a temperature of 105°F. to 110°F. If the water is too hot, it may remove the delicate detail.

If a dependable source of hot running water is not available, fill a large pail with hot water, and apply it to all parts of the stencil with a cup. Apply the water freely to both sides of the stencil until the soft gelatin is dissolved and the open parts of the stencil are clear. As soon as the screen is wet, the light may be turned on.

Now apply cold water to the screen. This stops development, and also removes loose particles of gelatin. Next, lay the screen on a soft, lintless cloth; place a similar cloth on top of the screen. Over this place a stiff piece of cardboard and press it down firmly with the hands over the entire surface of the screen. This will remove much of the moisture from the stencil and will also remove any remaining particles of loose gelatin or "scum." The stencil is then dried with an electric fan and taped. After this operation it is ready for use.

To remove a stencil from the screen after use, the following preparation may be used:

| Hydrate of ammonia 20 per cent | 4 ounces |
|--------------------------------|-----------|
| Sodium hydrate | 1 pound |
| Water | 2 gallons |

Caustic potash may be used instead of the soda. It is more expensive but is also more effective. Photo stencils may also be removed with a strong solution of Beat's salts, boiling hot, or by blowing the gelatin out of the mesh with a jet of live steam.

The Carbon Transfer Method.—This is the method which has long been employed by photographers in the making of carbon prints. It is also referred to as the transfer, gravure, or English method. The results obtained from carbon stencils have not been entirely satisfactory because of shrinkage, which is more difficult to control in stencils of this type than in those made by the direct process. However, owing to the facts that these are more convenient to make and that finer detail may be reproduced with them than with those made by the direct method, transfer stencils are being increasingly used by operators for all types of work in which a slight shrinkage does not impair the quality of the prints.

The materials used are Autotype Carbon Sheet No. 94 and Temporary Support No. 112, for which there is an American agent in New York. Eastman transfer sheets may also be used. The carbon sheet consists of an especially prepared backing paper coated with pigmented gelatin, all ready for sensitizing. It may be secured in sheets 8 by 10 inches in size, or in 4-yard rolls 36 inches wide. The temporary support is a thin gelatinized sheet which must be waxed before use. A sheet of plain glass, opal glass, polished copper, or thin celluloid may be used instead of paper for making the transfer, provided the surface is properly waxed.

Waxing.—The first step in making a stencil by the carbon method is to prepare the transfer or temporary support, as this should be waxed at least an hour before use. The waxing solution is:

| Beeswax | $\frac{1}{4}$ ounce |
|------------|---------------------|
| Rosin | $\frac{1}{4}$ ounce |
| Turpentine | 12 ounces |

Melt the wax in a water bath; add the rosin (preferably powdered); and finally add the turpentine, stirring constantly.

Take up a very small quantity of the waxing solution on a soft, lintless cloth and dab it on the transfer paper. Just a trace is sufficient. Then rub with another soft cloth until the paper has an even polish all over. Now lay the transfer paper aside until it is needed.

Preparing the Carbon Tissue.—Next, select a piece of carbon paper at least $\frac{1}{2}$ inch larger than the stencil to be made. Should the carbon tissue appear dry and liable to crack, it should be placed in a damp place for a few hours. It is advisable, in this process, to allow a narrow "safe edge" all around the copy, that is, an opaque margin at least $\frac{1}{4}$ inch wide, produced by painting with India ink or by pasting strips of black paper around the drawing. The object of this is to insure a soluble margin to the pigment paper, by protecting it from the action of the light during exposure. This margin will prevent washing out of the stencil at the edges during development.

Sensitizing.—The sensitizer is prepared in the following proportions:

| Water (preferably distilled) | 50 ounces |
|------------------------------|-----------|
| Potassium bichromate | 1 ounce |

Heat the water; pour in the bichromate; stir until it dissolves; then set aside to cool.

The sensitizer is then poured into a shallow dish or porcelain tray and the carbon sheet is fully immersed in it for 2 minutes. See that no air bells form on the face of it, because they will cause unsensitized spots on the paper. The temperature of the solution should not exceed 65°F. Place the wet sheet face down on a piece of glass and pass a squeegee lightly over the back to remove surplus solution. Then hang it up to dry.

The sensitizing may be done by artificial light, but drying should be done in the dark, and should take about 3 hours. The paper curls in drying and becomes crisp. In order to make it lie flat, some operators prefer to let the paper dry face down on glass. When dry, the paper leaves the glass. One objection to this method is that contact with the glass prevents air from reaching the wet gelatin, and drying may be prolonged for hours. A second objection is that the gelatin may stick to the glass unless the glass is well waxed.

Instead of immersing the carbon paper, the operator may apply the sensitizer to the paper with a soft brush. Five or ten minutes after applying the first coat, the operator should brush on a second coat, making sure that the whole surface is covered.

Exposure.—A spring-back printing frame, such as photographers use, may be employed in making the exposure. These frames may be purchased in various sizes up to 14 by 17 inches or even larger. If the special printing frame, described on page 132, has been constructed, it may be used in making the exposure.

The copy to be photographed is first placed in the printing frame, facing away from the glass front. The sensitized side of the carbon sheet is then placed in contact with the copy and the spring-back is fastened in place. If the sensitizing solution is of the same strength as the one used in the direct method, the resulting exposure will be the same.

Development.—After exposure, the print is taken from the frame and placed in cold water. The transfer paper, which was previously waxed, is also put in the water. The carbon sheet first curls in the water, then gradually flattens out. This is the moment to bring the two sheets together, under water, and then remove them to a sheet of glass, with the carbon paper on top. A squeegee is passed lightly over the back of the carbon sheet, to remove surplus moisture and air bells and to press the two sheets firmly into contact. Blotters are then placed on top; over these books or weights are placed and the whole is allowed to stand for 15 to 20 minutes. This is to give the sensitized gelatin time to adhere to the transfer support.

The next step is to remove the papers from under the blotters and weights and place them in water at a temperature of 105° to 110°F., with the carbon sheet again on top. In a few seconds gelatin will be seen oozing out between the two sheets. When this occurs, take hold of one corner of the backing paper, and, keeping it under water, gently pull it off. Only a formless mass will be visible at first on the transfer paper; but the soft gelatin is washed away, as development continues, until the image appears in hardened gelatin. Move the transfer paper back and forth gently in the water until development is complete; then place the print in cold water for a few minutes.

If necessary, a 5 per cent alum bath may be used to increase the hardness of the gelatin stencil. This bath will also remove any remaining bichromate stain. Before attaching the transfer paper to the silk, trim it down as close as possible to the copy.

Adhering to the Silk.—Now lay a piece of glass or smooth metal under the silk screen, and place the transfer paper upon it with the stencil facing toward the silk. Lower the frame. Rub the surface of the screen with a soft cloth to adhere the stencil. A moderate weight should be placed on the screen for 5 or 10 minutes; after this the screen should be placed upright in front of an electric fan to dry. When the stencil is fully dry, the transfer paper may be easily pulled away. Then paint around the stencil with filler, and tape the screen. It is now ready for printing.

The stencil will be rendered more durable if lacquer is brushed on the inside of the screen and then quickly wiped off from the outside with a rag moistened with lacquer thinner. Care must be exercised to prevent the lacquer from filling up the mesh.

If a glass or copper transfer sheet is used, the transfer material will serve as a firm, smooth base on which to attach the stencil to the silk. A piece of celluloid 0.0075 inch in thickness makes a convenient transfer, because its transparency and thinness make it possible to attach the celluloid to the carbon sheet immediately after the sensitizing operation. It then remains attached to the carbon sheet during the exposure and development of the stencil, and is removed only after the stencil has been finally attached to the screen and dried.

Carbro Stencils.—In the carbro or ozobrome method, stencils are made from bromide photographic prints. The stencils produced in this way are not sharp enough for fine work. For certain types of work, this is an economical method to use in making large reproductions, or "blow ups," from small originals. Or, if it is desired to make a number of small prints on one sheet of paper from a single original, this can be done by making ten or fifteen stencils from one bromide print and then placing all of them on the screen at once.

A regular photographic negative must first be made from the copy with a camera. The photographer then makes the bromide print on matt paper, in any size desired.

In this process, a carbon sheet impregnated with bichromate and ferricyanide is brought into contact with the bromide print. The metallic silver reduces these compounds, and the gelatin is hardened by contact with the silver so that it becomes insoluble in hot water, just as if it had been exposed to light. The operator must prepare two solutions for use in this process.

| Solution 1 | | | |
|---------------------------|------------|--|--|
| Potassium bichromate | 1 ounce | | |
| Potassium ferricyanide | 1 ounce | | |
| Potassium bromide | 1 ounce | | |
| Water | 20 ounces | | |
| Solution 2 | | | |
| Glacial acetic acid | 1 ounce | | |
| Hydrochloric acid, C.P | 1 ounce | | |
| Formaldehyde, 40 per cent | 22 ounces | | |

Dilute 1 ounce of solution 1 with 3 ounces water. Soak the bromide print in water. Place a sheet of paper carbon tissue in the dilute No. 1 solution for 3 minutes; allow to drain for 15 seconds; immerse in a quantity of solution 2 with 32 times its volume of water, for 20 or 30 seconds. Then place the wet carbon sheet on the bromide print, squeegee into contact, and leave for 15 minutes. The two sheets should be placed between grease-proof papers during this time to prevent uneven drying. The two are then stripped apart, and the bromide print is placed in a dish of clean water. After a thorough washing, it can be used at least 10, and in some cases, 15 times. The carbon sheet is pressed into contact with a temporary support which has been waxed and then soaked in water for 15 minutes. It is then treated as in the carbon process.

Water for development should be a few degrees cooler in this process than in the carbon process—at least to begin with.

Short immersion in solution 2 produces prints characterized by contrast; long immersion produces flatter ones, showing more detail. Longer contact between bromide and carbon sheet will give darker prints.

When finished, the bromide print should be washed and redeveloped with photograph developer. It can then be used for making more stencils if necessary.

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Other Photo Stencil Methods.—In addition to these processes for making photo stencils, numerous other methods, materials, and techniques have been used by operators within the past few years, with varying success.

Although all processes must be considered experimental until they have been thoroughly tested under practical working conditions, the fact that many minds are working toward a simple solution of the problems involved in making photo stencils is evidence of the increasing interest in and demand for such solution.

One method which has been successfully used calls for coating a sheet of zinc with gelatin and placing it on a whirling machine to spread the coating; after that, exposure, development, and adhesion take place; and finally, the zinc sheet is separated from the stencil. Sheets of colored gelatin, such as are used for stage-lighting purposes, have been attached to various surfaces, then sensitized, and used as stencil material.

In one method, a piece of silk is stretched on an extra frame, then sensitized, exposed, and developed; after this, it is cut from the frame and adhered to the regular printing frame by shellacking around the edges. A very coarse silk or copper mesh is used for the regular screen because this stencil is imbedded in its own fabric.

In another method, silk paper, like that used in duplicating machines, is sensitized, exposed, developed, and transferred to the screen. In yet another method, the stencil material consists of a layer of colored gelatin attached to a transparent paper backing, instead of the usual opaque backing. With this film, exposure is made through the back of the sensitized sheet. After this is developed, it is placed in contact with the screen, no intermediate transfer being necessary. In this method, the operator is able to see what the results of his work will be, before the stencil is attached to the silk. The advantage of this is readily apparent, when one considers how, if a stencil is spoiled in the direct method, the ruined gelatin must be removed from the silk, or a new piece of silk must be stretched on the frame and the whole process of sensitizing, exposing, and developing must be repeated.

Photo Printing Frame.—The printing contact frame, shown in the illustration, Fig. 67A, should be of a size which will permit the stencil printing frame B to be placed comfortably inside it. The front or printing side of the contact frame is covered with glass D, fastened in grooves in the frame or held in place by cleats. The thickness of the frame, when measured from the top of the glass on the inside, should be the same as that of the regular screen



FIG. 67.—Printing frame for photo stencils.

frame, so that, when the two frames are fitted together, their upper surfaces will be even.

A contact panel C must be provided, which will fit snugly into the regular screen frame. This panel, made of laminated wood, must be smooth and perfectly flat. Soft, heavy felt is fastened over one side of the contact panel, and a piece of fleece-lined muslin is stretched over the felt, fleece side up, and tacked to the sides of the panel.

Crossbars E, made of metal or hardwood, must be placed across the back of the contact frame. Flat-headed screw bolts F are inserted into holes bored through the sides of the frame. Holes must also be bored in the ends of the crossbars, so that they will fit over the ends of the screw bolts.

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To prepare for an exposure, the transparent drawing or photograph is placed, face up, on the glass of the contact frame. The stencil frame, which holds the sensitized screen, is then placed inside of the contact frame, and the panel is fitted into place. The crossbars are then placed over the bolts, and fastened down with wing nuts.

Miscellaneous Formulas

Quick-drying Sensitizer (Stock Solution):

| Potassium bichromate | $\frac{1}{2}$ 0 | ounce |
|-----------------------|-----------------|--------|
| Citric acid | 1/8 0 | ounce |
| Ammonia (28 per cent) | 3/8 0 | ounce |
| Water | 25 c | ounces |

By using $\frac{1}{4}$ ounce each of potassium and ammonium bichromates, ammonia may be omitted from the formula. This solution keeps well, if it is kept in a brown bottle or in a dark place. As needed, add $1\frac{1}{2}$ parts of alcohol to 1 part of solution. After alcohol is added, the solution must be used promptly because it deteriorates rapidly. It dries in 15 to 20 minutes.

Coloring Solution:

Violet anilin, water soluble $\frac{1}{2}$ ounceDenatured alcohol $\frac{1}{2}$ ounce

Dissolve, add 8 ounces of water, and strain. For coloring the gelatin, add enough dye solution to the sensitizer to produce the desired tint.

Stock Gelatin:

Soak 1 part gelatin in 7 or 8 parts water for 20 minutes; then dissolve by heat in double boiler. Add a few drops of carbolic acid as a preservative. Or, add alcohol in the proportion of 2 ounces alcohol to 10 ounces gelatin solution.

Transfer Tissue:

Soak 2 parts gelatin in 4 to 7 parts water; then dissolve by heat in a double boiler. Add $\frac{3}{4}$ to $1\frac{1}{4}$ parts sugar, mixed with enough lampblack to produce desired shade.

Put jelly in a flat dish while warm; free of bubbles. Hold paper upright at edge of dish; lower paper flat to surface of jelly. Raise with a slow, steady motion; allow to drip; and hang up to dry.

Another formula is: Nelson's No. 1 gelatin $\frac{1}{4}$ ounce; Nelson's amber gelatin 2 ounces; white sugar $\frac{1}{4}$ to $\frac{1}{2}$ ounce; white soap $\frac{1}{4}$ ounce; add water until total quantity is 10 ounces. Dissolve gelatin; add soap and sugar. Add lampblack 160 grains.

Temporary Support:

Coat thin uncoated cardboard or drawing paper with gelatin to size it. When it is dry, the gelatin coating should be partly hardened by immersion in a solution of 25 grains of chrome alum and 5 ounces of water. Then float on solution made of 1 pound shellac, 4 ounces borax, 1 ounce soda carbonate, 200 ounces of water. The supports should be waxed before use.

CHAPTER VI

MAKE-READY AND PRINTING METHODS

Thus far we have considered all the various screen-printing equipment, printing surfaces, mediums, stencil-making methods, etc., but there still remains the matter of coordinating the various elements and showing the steps of the process in practical operation. Nothing will do this quite so well as the description of an actual commercial job. Therefore, the production of the streetcar card, shown on page 137, will be described from the time the original drawing is turned over to the screen maker until the printed cards are ready for delivery.

This card, in red, green, and black, is to be printed on white show-card stock, and is of standard car card size, 11 by 21 inches. The selection of white stock makes it possible to use the color of the stock wherever white appears. If an uncoated stock had been selected, it would have been necessary to coat it with either white or red and print in the lettering. The size of the stock used is 12 by 22 inches, in order to provide a trimming margin sufficient to insure clean edges.

The original drawing, which is made 11 by 21 inches, is centered on the 12 by 22 card, the lettering parallel with the bottom edge of the card. Any divergence from the parallel will make it difficult to square up and trim the stock to the proper size, after the prints are made.

The next step is to decide upon the sequence of colors. This should not be merely a mental decision. The order of the colors should be written on the original. This written notation is not very important in this particular job because of the few colors called for, but, when many colors are to be printed, writing the order of the colors on the original will prevent any confusion later as to the order of making the various stencils. It will assist also in coordinating the printing of the colors with the order in which the stencils are made. In the present case, the sequence is red, green, black.

The card is first laid on the printing base and centered under the screen. When the best position of the card has been determined, the guides are fastened on the base, in order that the card may subsequently be placed in the same position for printing the other colors. The guides are usually placed near the corners of the bottom of the card, and along the lower left side. See Fig. 26.

For convenience in description, it is assumed that the stencils are to be cut in film. For registration purposes, the film cutter now traces cross marks at each corner in the margin which is to be trimmed away. He then cuts a piece of film large enough to cover the area to be printed, and fastens the film upon the drawing with Scotch tape. The registration cross marks should be duplicated on the film, being cut exactly over the crosses on the original.

The red stencil is then made by tracing the three lines of lettering, the words "Central Savings Bank," the irregular white panel in which the illustration appears, and the red parts of the illustration itself, as well as the margins which define the card. In all areas in which red appears, the film is stripped away, where the red meets the black a slight "overdraw" is necessary to facilitate registration.

Upon completion of the stencil, the original, with the film still fastened to it, is inserted in the guides on the printing base, and the screen is lowered. After first making sure that the film is in perfect contact with the silk, the stencil is adhered. The original drawing and the backing paper on the film are then removed and all the open space around the stencil is blocked out with lacquer. The stencil for the red is then ready.

A similar procedure is followed in making the green stencil. On this particular job, black is the key, or correc-



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OVER 215,000 DF MY PEDPLE SAVE AT CENTRAL SAVINGS BANK. TUMU don't you? TUMU don't you? TUMU don't you? CENTRAL AND POLNA DON'T YOU? FOUNDED 1859 FOUNDED 1859 FOUNDED 1859 FOUNDED 1859

Fio. 88.---Streetcar card in red, green, and black on white.

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The red is slightly overdrawn where it is to meet FIG. 68a.-The first color to be printed, showing the lettering in reverse. the black.

THE SILK SCREEN PRINTING PROCESS

tive color for the illustration. The black stencil is not overdrawn, because it is not to be followed by any other color.

After all the stencils have been made, they are turned over to the process man. It is his duty to check up on the register; reinforce the guides, if necessary; make sure that the hinges are tight; tape the stencil to prevent the possibility of paint oozing through at the edges of the frame; select a squeegee of the proper size and sharpness; and mix the paint.

In order to secure sharp printing where the white or reverse lettering appears, it is necessary that the paint be short in consistency. This is accomplished most often by the addition of transparent base.

After a few test impressions are run off, a print is compared with the original. If it is approved, the squeegee operator proceeds to run the job. He is usually assisted by a boy, often color to be printed. The called the take-off boy, whose duty is green is also overdrawn where it is to meet the to rack the prints.



FIG. 68b.—The second green is also overdrawn black.

The squeegee is moved across the screen from end to end (Fig. 24), the operator making sure that there is always enough paint in front of the rubber to cover the area to be printed. One filling of paint on the screen should last for 20 or 30 impressions. It is not advisable to pour too much paint on the screen, as this may cause the paint to overflow, making the printing sloppy and consequently causing finger marks to appear on the prints.

After pushing the squeegee across the screen, the operator lifts the frame. The card is removed by the take-off boy and placed in the drying rack. This completes the printing operation of the red.

After preparing to stencil the green, the operator runs off a few test impressions in order to make sure that the



FIG. 68c.-The third and final color. This color corrects the overdraws and completes the job.

registration cross marks for the green stencil appear exactly over those of the red impression. When the marks are found to coincide, printing is resumed with the green. A similar check of the registration must be made before printing in black. When the final color is thoroughly dry, the cards are ready to be removed from the racks, to be trimmed and packed, and then shipped. With proper teamwork, 300 prints of this size can be run per hour without rushing the work.

The job described here, being of a very simple nature, has not illustrated all the problems, methods, or operations which naturally appear in the course of many kinds of jobs, day after day. It will be necessary, therefore, to consider other important matters and situations which may be encountered more or less frequently.

Although a separate stencil must be prepared for each color, this does not necessarily mean that the old stencil must be removed and a new one attached to the screen each time a new color is to be run. In a great many instances it will be found that, in drawings which contain a number of colors, one color may appear only at the top and another color may appear only at the bottom, while small spots of still other colors may be scattered about the center.

In such instances, the stencils for several of these colors may be placed on the screen at one time, the one that is to be printed first being left open, while the others are temporarily blocked out with poster paper.

After the first color has been run off, the screen is cleaned with kerosene or turpentine, and the used stencil is painted out with lacquer or shellac. Then the paper that temporarily blocked out the second color should be removed. After the second color has been printed, the same operation of blocking out the old stencil and opening a new one is repeated until all the stencils on the screen have been used. The use of this short cut is not practicable when two colors meet, or where they are less than half an inch apart. In that event, it is advisable to put each color on a separate screen.

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When two colors are adjacent in screen printing, the stencil for the first color should be slightly overdrawn on the adjacent side, so that it will print about $\frac{1}{16}$ inch beyond its true boundary. This overlap is provided so that when the second color is printed, any slight discrepancy which may occur in the registration will not result in a conspicuous gap.

It is an old, although not ironclad, rule in screen printing that the lighter colors are printed first.

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There are occasions, especially in processing large signs, when a fairly wide space appears between the various colors. In these cases it may be possible to print two or more of the colors at one time. This is done by dividing the screen into compartments made of cardboard, attached to the screen by means of kraft or gum paper. Each compartment is made to enclose one of the colors on the screen.

The colors are poured into their respective compartments, squeegees are provided to fit into the compartments, and the colors are squeegeed in rotation. If several squeegee operators are used, any number of colors may be printed simultaneously.

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When paper or a lightweight cardboard is printed, the stencil has a tendency to lift the material with it as the screen is raised. When the card is removed from the stencil in this way it is likely to get blurred or smeared. One way to overcome this sticking is to nail small clips so that they project slightly over each of the three guides. As the card is fed into the guides, it is slipped under these clips and is held in position. When the stock is slightly curled or warped, these clips also help keep the stock flat and temporarily locked in the guides.

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It may be necessary, from time to time, to wipe the under surface of the stencil with a cloth to keep surplus paint from smearing around the printed areas.

If the paint seems to be too thick, it should not be thinned in the screen. The paint should be removed from the screen, thinned to the right consistency, and then poured back in the screen.

If the silk is not stretched tight enough, there may be a certain "give" or wavy movement of the silk as the squeegee passes over it. This may cause a double or blurred impression. One way to correct this is to fasten several layers of gum tape close to the blurred area on the underside of the stencil. Building up the screen in this manner causes the silk to pull away from the cardboard with a snap as soon as the squeegee has passed over it, and eliminates the blur.

Usually no pinholes appear in stencils made with film unless too much thinner has been used in adhering the stencil. However, if pinholes do appear, they can be blocked out with water color, lacquer, shellac, or glue. Black lacquer is the most suitable medium for this purpose, because it dries very quickly and is clearly visible on the screen.

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Usually on very short runs it is necessary to wait some time for each color to dry before starting the next one. Ordinarily prints should dry for at least 1 hour before the next color is printed. The first color will dry much faster than any other because it is run directly on the raw stock, and so is quickly absorbed by the paper.

To remove surplus paint from the screen at the end of a run, the easiest way is to scoop up the paint with a squaresided candy scoop, or with two pieces of cardboard held together to make a V-shaped trough. Scooped up in this way, the paint can be put back into the can with practically no waste. After removing the paint, both screen and squeegee should be thoroughly cleaned with turpentine or kerosene. This should be done at once, because it is difficult to clean the mesh of the silk properly after the paint is allowed to dry in it.

STRETCHING SILK OR ORGANDY

There is no fixed method for stretching the silk. Each operator has a method of his own which he thinks the most efficient. But for the benefit of the beginner, one satisfactory method will be described, as a suggestion.

Lay the frame flat on a rigid table and cut the silk to a size at least 1 inch larger than the frame. Put the fabric over the frame, keeping the threads parallel to the sides of the frame. Then fold the edges of the silk under and drive a tack into each corner, on the top of the frame. These tacks serve merely to hold the silk in position until it can be stretched and tacked permanently.

A strip of oilcloth 1 inch wide should be stretched over the edge of the silk to keep it from being damaged at the points where the tacks are driven.

Now put a No. 4 carpet tack in the hinged side of the frame at the middle, and continue tacking from the middle

toward each end, placing the tacks about 1 inch apart. The tacks should be fully driven in, so that the silk is held by the head of the tack rather than by the shaft. Very little stretching is required when tacking the first side. Then tack the opposite side, again starting from the middle and working toward the ends, pulling the silk outward from the center so as to stretch it taut, with a minimum of wrinkles. Now tack the ends. If the work is done



FIG. 69.—Stages in stretching the stencil fabrics.

properly, the tacking and stretching of the last end will remove all wrinkles from the fabric.

Organdy is fastened to the frame in the same way as silk. Organdy should not be pulled so tight as silk, however, because it has neither the strength nor the elasticity of the latter, and has, moreover, a tendency to tear, especially at the point where it is grasped. It is, therefore, much more difficult to stretch organdy than it is to stretch a fine grade of silk.

It is possible to make silk more taut by wetting both sides of it with water and letting it dry naturally after it has been stretched. Organdy should never be washed. Water removes the filler from it and makes the fabric loose and baggy.

After the silk or organdy has been tacked to the frame, gum paper, cut to the length of the respective sides of the frame, should be pasted over the tacks. This will help to seal the edges, and at the same time will reinforce the screen. Now turn the frame over and apply gum paper in much the same way on the inside of the frame, but this time crease the paper lengthwise so that, when applied, half of it will go on the silk and half on the side of the frame. This will prevent the paint from oozing and will eliminate the formation of pockets.

COLOR REGISTRATION

Accurate registration of color is just as essential in good screen-process work as it is in any other form of multicolor reproduction. Silk screen workers, lithographers, and letterpress printers use cross marks on the original as an aid to registration.

Before making the stencil, it is necessary to make the size of the original correspond to that of the stock to be stenciled. This may involve trimming the original, if it is too large, or mounting it on a larger piece of cardboard, if it is too small.

If the original drawing is somewhat rough and the various colors have indistinct boundaries, it is best, before proceeding with the making of the stencils, to outline the boundaries with a hard pencil. Then the pencil lines are followed, rather than the doubtful limits of the color areas. This will aid in accurate registration.

Regardless of the type of stencil to be made, at least two sets of short intersecting lines or cross marks are drawn on the original, preferably a cross mark in each corner. Care should be taken to place the cross marks so that they will not conflict with the area to be printed.

In many cases the stock used is somewhat larger than the print to be made, in order to allow for trimming after the

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prints have been completed. In such cases it is possible to print the crosses on the margin. If the various colors are run off in exact register, the crosses on each stencil will print exactly over the crosses on the previous color. If the registration is faulty, the amount by which the cross marks fail to coincide will indicate the degree of misregister.

In some instances, the original drawing may fill the whole surface of the illustration board, without any margin. In this event, the registration marks must be placed in some convenient area within the design, where no color is to be printed. The same procedure must be followed when prints are made on material too small to allow a margin for trimming.

In making knife-cut stencils, the stencil material is placed on the original and fastened in place with Scotch tape. The cross marks which appear on the original should then be duplicated on the stencil material. It is advisable that the operator do this before he cuts the stencil itself, so as to be able to detect any shift in the material during the making of the stencil.

In multi-color work, one of the colors may appear in only a very small area. In order to economize on stencil film, it may be desirable to use a piece of film just large enough to cover that particular color. This small piece of film must be fastened with Scotch tape over the cross marks on the original, and the crosses must be cut in it. When the stencil is adhered to the screen, the cross marks are attached as if they were part of the stencil.

Upon completion of the stencil, the original, with the stencil attached, is put in position on the base and the printing guides are fastened in place. The stencil is now ready for adhering.

If the cross marks appear within the design, a few cards or impressions should be run off first. The cross marks are then blocked out on the stencil with a filler or with gum paper. These few cards upon which the crosses appear are saved for use as master prints for checking the register of the subsequent colors. As a preliminary step to printing each of the remaining colors, the master prints are first placed in the guides and stenciled. If registration is found to check, the cross marks are then blocked out before the printing operation is resumed. If the cross marks have been placed in the margin, where they do not interfere, they may be allowed to print throughout the job.

Registration may also be checked or tested without squeegeeing paint through the screen. This is accomplished by tapping dry or powdered color through the screen on to the card. Since the dry color will not clog the mesh the stencil requires no cleaning. A snap of the fingers on the taut screen, or blowing over it, will remove the powder from the screen.

To register brush-made stencils, such as the resist or block-out types, the following procedure is suggested: Place the original on the printing base and establish its position definitely by fastening the guides. The stencil is then traced with pen or pencil, the cross marks being traced as well. A stencil that is thus fully traced may be filled in on the printing base, to which it is hinged, or, after being released from the hinges, the frame may be placed on the drawing table or any other convenient place for the filling operation. The cross marks are, of course, duplicated on the stencils with the same medium so that they will allow penetration of the paint. The frame is then re-hinged and ready for printing.

If a brush-made stencil is to be made on a sized silk directly over the original, no tracing is necessary. Again, the cross marks drawn on the silk must be left open.

The above procedure, dealing with both knife-cut and brush-made stencils is followed in the preparation of the stencil for each color.

If, for any reason, the cross marks on prints show a tendency to be out of register the same way in all four corners, it may be possible to change the position of the

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card so that the original marks will coincide. This is done by moving the guides until the cross marks on the stencil are immediately over the cross marks on the card or the original. When metal guides are used, it is an easy matter to shift the guides into the desired position by tapping them slightly with a hammer. It will be necessary then to reinforce them so as to offset any play that may have been caused by shifting their position.

SHADED OR BLENDED COLORS

Although screen printing is best adapted to flat-color reproduction, there are occasions when a limited amount of shading or gradation of tones is possible.

For instance, it may be desired that the color of a sky should vary from a deep blue at the top to a pale blue at the horizon. The several shades of blue which may be required to produce this effect are mixed separately. The stencil is prepared in the usual manner, just as if the whole area were to be printed in one solid color.

If four or five different shades of blue are to be used, a quantity of each is placed separately on the screen in proper order, the darkest color appearing at the top and the lightest color appearing at the horizon. These several patches of color are all squeegeed across the screen at one time, the squeegee being moved with as straight a stroke as possible.

The first few impressions will show distinct bands of the different tones. As the colors on the screen gradually become mixed, however, they will appear on the prints evenly shaded from dark to light. Since there is nothing on the screen to keep the colors separated, they will slowly blend and eventually neutralize each other, unless they are replenished in the same sequence. It can be seen from this that the operation is a rather slow one and that there will be some variation in the prints.



FIG. 70.—Poster printed in transparent colors with shading in the sky and water.

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DECALCOMANIAS

Decalcomanias, or transfers, are made by printing designs on paper which has first been coated with a water-soluble paste or gum. When the transfer is moistened and pressed against the surface on which it is to appear, the coating softens and permits the paper to be removed, leaving the printed design on the surface.

The methods of making decalcomanias by the screen process have been much improved within the last few years, so that screen shops now print them almost as easily as they print on cardboard.

Screen-process decals are used for placing trade names and advertisements on fleets of trucks and busses; for putting designs on toys, furniture, machinery, etc.; for window signs; and for any other advertising and decorative purposes where it is not practicable to print on the surface directly.

One problem frequently faced by the screen printer in the making of decals arises from the expansion and shrinkage of the paper caused by atmospheric conditions. Some screen shops store the printing paper in boxes containing water, so that the extra moisture will prevent the paper from curling. Sprinkling the floor of the processing room is sometimes resorted to, while the work is in progress. In very hot or very damp weather, it is sometimes necessary to keep the windows closed.

There are two kinds of decal paper in common use, simplex and duplex. Although it can be made in the shop, decal paper which is purchased from supply houses is much more satisfactory.

Simplex paper may be made as follows: Select a good smooth book paper, about 20 by 30 inches. Coat the paper with a thin solution of starch and gum. When dry, re-coat. Lay the sheets flat to dry, as hanging will cause them to curl. When they are dry, stack them and leave them to season for several days. To make duplex paper, attach a thin tissue paper to a fairly heavy, smooth, white paper, using a thin paste solution. When this is dry, coat the face of the tissue with a solution of paste and gum arabic.

Three kinds of decals may be printed by the screen process: the slide-off transfer, the direct transfer, and the varnish transfer. Either kind of paper may be used to make any of the three kinds of decals, although simplex paper is generally used for the slide-off type, and duplex paper for the varnish type.

The usual stencils are employed and printing may be done with either lacquer or gloss oil colors. Some manufacturers use only lacquer, because of its quick-drying nature. Others stencil long oil colors between two coats of lacquer. Whatever the method, more durable results will be obtained if a coat of either lacquer or varnish is stenciled on the decal paper before the colors are run. The stencil should be saved, in order that another coat may be applied after the last color is run.

If part of the design is to be transparent, or if a line of lettering must appear without a background color, lacquer may be processed on the paper before stenciling the design. In this case, it is advisable to apply a coat of lacquer both before and after the design is printed, as in this way, a tough, thick film will be provided to protect the design.

If slide-off transfers are to be used on opaque surfaces, the colors are printed in the same order as when printing on cardboard; that is, a solid background would be printed first and the lettering or design printed over it. The design appears face up on the finished print. If the transfers are to be used on the inside of windows, they must be printed in reverse so that the lettering will read correctly from the outside of the window.

The transfer is applied by dipping it in water for a few seconds then placing it, paper side down, on the surface which is to receive it. While still wet, the design is pressed down slightly with the fingers of the left hand, the edge of the backing paper being grasped by the right hand and gently slid from underneath. When the printed design comes in contact with the receiving surface, it carries with it enough of the adhesive to hold it in place.

Direct transfers are printed in reverse when they are to be applied to opaque surfaces or to the outside of windows; but are printed right side up when they are to be applied to the inside of windows. Transfer is made by sliding the printed design off the backing paper; but in this case, the transfer is placed face down on the receiving surface and the backing paper is slid from the top of the transfer, instead of from the bottom as was the case in the previous example. To facilitate this technique of application a special adhesive must be applied to the transfer after all the colors of the design have been printed. In order that a transfer of this type may be attached in the exact position desired, it is advisable that the outlines of the design be printed on the back of the transfer paper in pale blue. This outline serves as a guide in placing the transfer exactly in the proper position.

The transfer must first be dipped in water for a few seconds, then applied to the receiving surface, and smoothed out with a rubber roller or squeegee. After this, the backing sheet is lifted or slid off; the print being left in place.

Although the varnish transfers printed on duplex paper may be used on either the inside or outside of windows, they are particularly suitable for use on trucks, busses, and wood or metal outdoor signs.

When they are to be used on the inside of windows, the transfers are made right side up. When they are to be used on solid surfaces, they are made in reverse; that is, the lettering must be printed backward, and the usual sequence of printing the colors must be reversed as well. A tracing of the original design must therefore be made on thin tracing paper, and then placed upside down under the stencil material, so that the design will be traced on the stencil in reverse. Before the colors are stenciled, a good coat of clear lacquer, or of heavy, tough-drying varnish, should be stenciled on the transfer paper. This coat should extend at least $\frac{1}{16}$ inch beyond the design on all sides. The coating stencil should be saved, in order to run another coat of varnish over the print after the colors have been printed. The varnish should be pale colored so as not to discolor the designs. A coat of varnish on both front and back of the transfers will protect them from the weather and prevent oxidation of the colors. Gold is especially liable to tarnish upon exposure to the air, and should be protected.

Slip sheets should be inserted between the transfers after the printing operations have been completed in order to keep them from sticking together.

The surface on which a transfer is to be applied should be clean and free from grease. A special decalcomania varnish is used to adhere the print to the final surface. The varnish may be applied either to the transfer or to the receiving surface. As soon as the varnish becomes tacky, which may take from 20 to 30 minutes, the print is applied and smoothed out with a squeegee or soft cloth. It is then left an hour or more to dry, after which the backing paper is peeled off and the tissue second sheet is wetted until it slides off the print.

ETCHING MIRRORS AND METALS

The screen process is widely used for etching designs on mirrors. Manufacturers of mirror novelties employ the process for applying designs to mirrors for household use, for making mirror numerals on clock dials, etc., and for combining mirrors with clear glass and colors to produce an interesting variety of displays for advertising and decorative purposes.

Either gold, silver, or blue gun-metal mirrors may be used. Quick-drying asphaltum is then stenciled over the entire silvered side of the mirror except on the parts that are to form the design. When this is completely dry, the design is
MAKE-READY AND PRINTING METHODS

opened up by flowing over the entire surface a solution consisting of 60 per cent water and 40 per cent nitric acid of 10 per cent strength. Wherever the mirror is not pro-



FIG. 71.—A display printed on glass in which the lower half is a silvered mirror with the advertising copy printed in four colors at the top.

tected by asphaltum, the acid will etch away the silver, leaving the design in clear glass.

As soon as the acid solution has dissolved the silver, the solution is washed off by placing the mirror in running water. The asphaltum resist is then removed from the mirror with turpentine.



FIG. 72.—This illustration shows the first stage of printing a design on a glass mirror. In this case the decoration was first printed on clear glass with lacquer. A silvering solution was then flowed over it.

If it is desired to give color to the design, the colors may be applied to the clear glass, from the silvered side of the mirror, either by stencil or by hand. Nitric acid is very corrosive and should not be permitted to touch the skin. It should be applied either by flowing on or by daubing with a rag tied to the end of a stick.

This method may also be used in etching designs on steel, brass, copper, aluminum, or chromium-plated metal, provided the proper etching solutions are applied to the various metals.



FIG. 73.—Clock dial with numerals and center panel in silver.

ETCHED FROSTING ON GLASS

Frosting.—Formerly, designs were etched on glass by sandblasting or by dipping the glass in various etching solutions, which consisted chiefly of hydrofluoric acid. This acid is particularly disagreeable to work with, because contact with it destroys the fingernails and produces bad sores on the skin. Since it also destroys glass, it must be stored in paraffin-lined bottles or lead carboys.

These methods are still used whenever it is necessary to etch the design deep into the glass. For making frosted patterns, however, compounds are now obtainable which, when used in the screen process, eliminate the hazards of the older methods, and make the work quicker, more economical, and safer.

Frosted designs may be applied by the screen process to glass signs, display cases, mirrors, household glassware, or any other glass surface. A design may be etched on the back of a mirror before the silver is applied, or applied to the front of the glass after it is silvered. The noninjurious nature of the frosting compound makes it particularly well suited for use in vocational schools and by amateurs for whom the former methods would be unsafe.

The stencil is prepared in the usual way, and the compound is used like paint or any other printing medium. The glass to be etched must be thoroughly cleaned with alcohol. The compound is then stenciled on the glass and left in place for 2 or 3 minutes, after which it is merely washed off with water, the glass being allowed to dry. This medium functions best at a temperature of 60 to 75°F. In higher temperatures, the 3-minute period should be shortened to prevent the edges of the design from blurring.

Imitation Frosting.—There are also several ways to make imitation frosting effects. Special lacquer pastes are sold for this purpose. Or, extender, with a small amount of varnish and drier added, may be used as a medium. Another medium is prepared by grinding an inert substance, such as whiting, asbestine, magnesium carbonate, or linolith, in a mortar with mixing varnish.

A tough scratch-proof imitation frosting may be made by adding a very small amount of white ink to bakelite varnish. If it is necessary to thin this varnish, a high-boiling-point tar naphtha should be used. The stenciled frosting dries overnight. Since the degree of its translucency depends upon the amount of ink added to the varnish, this frosting may be produced in degrees of opacity varying from that of ground glass to that of opal or milk glass.

TEXTILE PRINTING IN COMMERCIAL WORK

Equipment.—The printing tables used in the large commercial textile plants are from 60 to 80 yards long, 64

inches wide, and are constructed of wood or metal. A length of 60 yards is sufficient for processing all kinds of silk material; whereas, for processing cotton goods, a length of 80 yards is necessary. A width of 64 inches is sufficient for handling all standard bolts of cloth, the widest being linen, which comes in widths up to 54 inches.



FIG. 74.—Textile printing equipment.

Wooden Tables.—Wooden tables are covered with a layer of extra-heavy felt about $\frac{1}{4}$ inch thick, which must be in one piece without seams. On top of the felt is also stretched a covering of extra-heavy oilcloth. This table must be constructed of well-seasoned wood, the top being made of $\frac{3}{4}$ - or 1-inch panel board. On this table the printed cloth is dried by a series of electric fans conveniently spaced along the table.

Metal Tables.—The framework of the metal or steam tables consists of angle irons, and the top is composed of asbestos plates, which retain the heat without expanding or warping. Several rows of 1-inch steam pipes extend the length of the table under the asbestos plates.

Stretching Rollers.—In order to stretch the cloth lengthwise, it is attached to rollers at each end of the table, one of the rollers being fitted with a ratchet arrangement for rolling up the cloth to the desired tightness. The cloth is then stretched crosswise by fastening it to the table with ordinary pins.

Angle Iron and Registry Guides.—Along the top of the table and extending its length, is a cold-rolled angle iron or rail, 2 by 2 inches, which must be screwed down very accurately in order to carry the metal "contact stops" or registry guides. These stops are placed at fixed intervals along the rail and fastened in place with thumbscrews. The distance between the stops varies with the size of the unit or repeat. A special tool is used to measure off the repeats.

Stencils.—The stencils are made like tusche stencils, except that, instead of glue, caustic-resisting bakelite varnish is used for the filler. The screen is first coated with a thin solution of dextrin. Then the design is painted in with a water-soluble resist material, such as tusche. When the resist is dry, the varnish filler is scraped over the screen. After the varnish dries, both sides of the screen are washed to remove the dextrin and the resist. Next, the screen is reinforced from the back with the bakelite varnish, which is quickly removed from the open spaces by a wash of turpentine. Such a stencil is acid- and caustic-resisting, and will last-indefinitely if it is properly used.

Stencil Frame.—The stencil frame is made of about $1\frac{1}{2}$ - by $2\frac{7}{8}$ -inch sugar-cured California pine, on which is stretched No. 10XX silk of best quality. One- and one-quarter-inch screw eyes are placed near each end of one of the narrow sides of the frame for contacting the rail. These screw eyes serve as a means of adjusting the up-and-down register. By screwing the eyes in or out, the frame is moved closer to or farther away from the rail.

MAKE-READY AND PRINTING METHODS



FIG. 75.—Silk dress material printed with dyes by the screen process.

A small angle iron should be attached to the top of the printing frame, about 7 inches from the left side. When the frame is moved along the table, this angle iron is brought into contact with the registry guide, thus controlling side-to-side registry in the same way that the screw eyes provide control of the up-and-down registry.

Squeegees.—Although both rubber and wooden squeegees are used, the wooden type is by far the more popular because it makes the dye penetrate the cloth better. Wooden squeegees are made of soft white pine, tapered at one end like a wedge. A separate squeegee is used for each color.

In the printing operation, the squeegee is scraped the full length of the stencil, then scraped back to the starting point. Inasmuch as fine silks and chiffons take the dye very quickly, they are usually given two scrapes. Heavy silk is given four scrapes; fine linen, two to four scrapes; Irish linen, about ten scrapes.

Dyes.—The dyes used are of four distinct families, listed and described below.

1. Application Chrome Colors.—These are used for printing on cotton and low-priced silks and are not very fast. Chrome colors are used only on light backgrounds. The dyestuff is cooked in water to a boil, then a quantity of thick gum tragacanth is added as a thickening agent.

2. Discharge or Acid Colors.—These colors are used on the better grade of silk and chiffon, and are fairly fast. They may be used on a background of any color, including black.

3. Repitigen or Caustic Colors.—These colors are of recent development and are now used on perhaps 90 per cent of the materials used for draperies, handkerchiefs, tablecloths, etc. They are absolutely tub-fast and are very brilliant. Because of the caustic nature of these dyes, the life of the stencil is comparatively short. Repitigen colors are used on light backgrounds. They are more brilliant than application colors. 4. Vat Colors.—These colors are not very popular, being used mainly for shirt materials. They are so fast that, when errors are made, removal of the color for correct reprinting is almost impossible.

Textile Lacquers.—Lacquers for printing textiles have recently been placed on the market, but as yet are made only on order. The lacquers are used chiefly on the less expensive fabrics, which are not perceptibly stiffened by their use. The lacquers are washable and comparatively sunproof.

The equipment and methods employed are the same as for printing with dyes, unless it is desired to use the lacquers to produce a raised or embossed pattern on the cloth. Suitable retarders and thinners are used to maintain the colors at workable consistency.

The use of lacquers makes it unnecessary to wash the cloth for the removal of foreign matter prior to stenciling, and also renders unnecessary some of the steaming and washing operations which are necessary when dyes are used. Another advantage in the use of lacquers is that their use obviates many of the uncertainties and difficulties usually experienced in matching delicate dye colors. Those who have had experience in matching dyes know how difficult it is to foretell what shade a dye mixture will ultimately produce.

Processes.—*Preparing the Material.*—The "green" or raw material is first "boiled off" in water to remove impurities. Then, in order to make the cloth take the colors better, it is given a preparatory dyeing by immersing it in a dye of the same type or family as the dyes with which it is to be printed.

Machine Framing.—In the boiling off and preliminary dyeing operations, a definite shrinkage of the material takes place. In order to correct this shrinkage before printing, the cloth must be placed in a frame machine which stretches it to its original width. *Printing.*—Before printing is begun, a layer of cheap cotton is stretched over the top of the table to absorb or blot up any excess color which may penetrate the material. The cloth to be printed is then placed on the table, attached to the rollers at each end, stretched to the desired tightness, and pinned along the edges. The adjustable metal registry stops on the rail are then set at the desired intervals for obtaining the repeats; the angle iron on the stencil frame is moved up against the stops; the frame is then lowered, with the screw eyes in contact with the rail. The first unit may now be printed by scraping with the squeegee as many times as necessary for the material.

After the first impression is made, the frame is lifted and moved up to the third stop. The second stop is omitted for the present so that the frame will not pick up wet color from the previous impression.

Finishing.—Upon completion of the printing operations, material printed with application colors is put in a special steamer for about 35 minutes to set the color permanently. The cloth is then put through a continuous washer, traveling through several tubs, the first of which contains a soap solution, the other tubs merely containing plain water for rinsing. This washing removes the gum tragacanth base.

The material is then put through a "hotbox" for drying, is again "framed" back to its original width, is then run through a calendering machine for further softening, before being bolted for final disposition.

If discharge colors are used, the material goes through the same finishing operations described above, except that it is given a 4-minute steaming to "develop" the color, before it goes to the 35-minute steam "fastening" process.

Repitigen colors are developed by an acid fume system and are then given the same treatment as application colors. The acid fumes bring out the brilliance of the colors.

Washing Out Stencil.—After the printing has been completed, the color is removed from the stencil with a spray of water at high pressure.

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TEXTILE PRINTING FOR AMATEURS

The method employed by students, amateurs, and workers in the small arts and crafts studios for printing scarves, dresses, collar-and-cuff sets, pajamas, lampshades, wall hangings, piano covers, table covers, emblems, and other small novelties is basically the same as that used in the large textile plants. Many adjustments must be made, however, because of the fewer facilities at hand and because of differences in the sizes and types of material to be printed.

The materials most generally used are flat crepe, satinback crepe, Canton crepe, crepe de Chine, chiffon, pongee, georgette, etc.

All material must be free from any loading or weighting. Loaded material must be washed in water to remove the foreign matter.

Any ordinary processing table of the proper size may be used, provided it is covered, first, with a layer of felt about $\frac{1}{4}$ inch thick, then with a layer of oilcloth, and finally with a top layer of cheap calico to absorb the excess dye. The calico should be removed from the table frequently for washing.

A rail with ruler markings on it should extend along one edge of the table. The rail should be equipped with movable metal stops or registry guides. These are particularly necessary if repeat motifs are to be printed. If desired, a smooth, straight board may be substituted for the metal rail and nails may be driven into the wood to serve as registry stops.

The material is stretched over the padding and pinned down securely, care being taken that the cloth has no creases or wrinkles in it.

Only application dyes should be used. After pouring a quantity of the dye paste into the stencil frame, move the squeegee across the stencil with an even sweep, applying firm pressure. At the end of the stroke, lift the squeegee. Then set it down again over the mass of color, and make the return stroke.

Dyed material dries a full shade lighter than it appears while wet. This must be borne in mind when deciding how many scrapes a piece of material should receive. In order to prevent smearing and to expedite the work, print only every other space, so that, by the time the end of the table is reached, the first spaces printed are dry enough to permit dyeing the alternate spaces.

As a check on the registration of the various colors, tiny cross marks may be left open in the margin of the cleth. These marks should be small enough to be inconspicuous on the finished material, but plain enough to serve as guides for registering the several impressions.

Small steam boxes may be purchased for setting the colors in printed material. Those who do not feel inclined to make this expenditure can usually arrange to have work steamed at reasonable rates by the dealer who supplies the dyes. If a supply of steam is available, homemade steaming equipment may be contrived. A long, upright metal box must be built by a plumber. A steam pipe is then attached to the bottom of the box and some means of escape for the steam must be provided at the top of the box. The temperature in the steamer should be maintained at 200°F. for 3 consecutive hours.

If the printed work is to be sent by mail for steaming, lay a large piece of heavy paper on a table and on top of the cloth place two or three pieces of clean white wrapping paper. Place a piece of dyed material on the white wrapping paper, and cover with more paper; repeat this process until all the material to be steamed is taken care of. The whole is then rolled without wrinkles or creases around a 2-inch mailing tube and tied in several places with a stout cord. Then wrap the cylindrical bundle with heavy wrapping paper, making sure that two or three thicknesses of paper securely cover the ends. After the steaming, the cloth must be rinsed thoroughly and carefully in lukewarm water. The cloth should not be folded or wrinkled, nor should it stand in water, because the dye may spread through the whole fabric. After the first washing, it is not necessary to be quite so careful, but even then, the cloth should not be rubbed by hand.

Partly dry the material by wringing it between two pieces of white cloth. It must not be dried by wringing or twisting it against itself, as this might cause some excess dye to stain the material. Then apply a moderately hot iron to restore its smoothness and lustre.

For those who have but little working space, a simple method consists in first printing an outline of the desired design, to act as a key or guide for the remaining colors. When dry, the color paste acts as a resisting agent which permits the spaces remaining in the design to be brushed in with a liquid dye. This method is especially useful when the design involves a large number of colors.

In this combination method of screening and hand painting, the cloth is stretched on a wooden frame after the key color is printed and dried.

CHAPTER VII

FINISHING

The finishing operations include trimming, scoring, bending, folding, and mounting easels on displays; attaching eyelets or grommets; stapling; die-cutting; weatherproofing; slip-sheeting; mounting pictures, overlays, dummy boxes, etc., on the displays; packing in bulk or in individual containers for shipment; and any other operations that may be necessary.

If there is a large amount of finishing to be done, the displays are usually sent out to firms which specialize in that particular work. Frequently the mounting and finishing are done in the silk screen shop, especially when the quantity is very small.

When irregular shapes are to be cut in small quantities, the work may be done with a cut awl. This is a portable, electric cutting machine with a small cutting blade which moves up and down like a sewing-machine needle. This portable cutter can be manipulated with ease, and can cut through material up to 1 inch thick.

For finishing work on the premises, the screen shop should also possess an electrically heated gluepot and bristle brushes for gluing easels, mounts, etc.

Glue may be obtained in either liquid or crystal form. Liquid glue can be used either hot or cold, but crystal glue must be heated in order to liquefy the crystals.

Weatherproofing.—It is advisable that all outdoor cardboard posters and displays be varnished both front and back, and along the edges as well. This will seal the display in a coating which will protect it from rain or snow. The varnish will also brighten the colors, minimize scratching, and make it possible to clean the display more easily. For

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this use, overprint varnish is much more durable than spirit varnish.

Mark-out Sheets.—It is essential that the position of the guides used during the printing operation be drawn on the printed card which is to serve as the master or mark-out sheet for squaring up the work for plain trimming, or to



B

FIG. 76.—Posters varnished front and back for weather protection. A is a truck poster and B is an outdoor hanging sign printed on "pressed-wood."

serve as an accurate guide from which to make the tracing for die-cut work.

Trimming.—The prints should, of course, be fully dry before they are trimmed. The trimming may be done either by a hand cutter or by a power cutter or guillotine. On a hand cutter, each card is trimmed individually. On a power cutter, a number of cards are cut simultaneously.

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During the cutting operation, pressure is applied to hold the cards in place as the blade strikes down. This pressure may cause the cards or prints to offset unless they are thoroughly dry.

Die-cutting.—Die-cutting is a mechanical means of cutting irregular shapes by making a die and stamping the card or display with the metal die blade. In making a die, the die-cutter traces the irregular shape of the display on a



FIG. 77.—Three-piece window display printed in 10 colors, varnished and die-cut.

heavy-ply board, then jig-saws the tracing along the contour. A special, flexible-steel ribbon with a sharpened edge is then inserted in the tracing, with the sharpened edge projecting. The sides of this projecting steel ribbon are protected by padding or by numerous rubber cushions, so that, when the display is die-cut, the cushions act as shock absorbers. If there is much die-cutting to be done, it is advisable to have the work done by specialists in that field, as it not only involves the use of special machinery and skill but physical danger in the manipulation of the press.

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When printing designs that are to be die-cut, the guides should be so arranged that registration of the card under the



FIG. 78.—Three-plane display on which tusche-resist stencils were used for the pictorial work and film stencils were employed for the lettering.

stencil is made with right-hand feed. It is a standard practice with die-cutters to register all die-cutting from the

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FIG. 79.—Effective combination of two distinct graphic reproduction methods. The portrait was printed by four-color process and mounted on the back panel. The main part of the display was printed by the screen process.

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right side; hence, it is essential that both the printing and the die-cutting be registered from the same side.

For the parts of the design that are to be die-cut, the stencil should be made to print at least $\frac{1}{8}$ inch outside the margin of the design. Die-cutting may not be entirely accurate, and allowing a $\frac{1}{8}$ -inch or wider "bleed" on the prints will take care of any inaccuracy in the finishing of the display.

Designs to be die-cut should be printed with a paint made resilient by the addition of flexible, slow-drying varnish. The reason for this is that when the steel die cuts through the card, the paint may chip and crack along the edges unless it is slightly flexible.

Single-wing and Double-wing Easels.—Either single- or double-wing easels are used. These are kept in stock by finishing plants, in standard sizes ranging from 2 inches to over 40 inches in length. The double-wing easel provides the best support for holding the display upright. Easels which have either a flat or slanted bottom may also be obtained. The straight-bottom easels will hold displays perfectly vertical, and slanted-bottom easels permit the displays to tilt backward slightly. Displays which are designed with a large panel in the center, flanked by a small panel or wing on each side, do not require the use of easels. When displays of this type are set up for use, the scored side panels are set forward at an angle to the center panel, thus preventing the display from falling over.

Gluing.—In many cases it is more economical to apply glue by the screen process than by brush. First a stencil is made, corresponding to that part of the easel which is to be glued; then by means of it the glue is stenciled directly upon the easels. As fast as the easels are stenciled, they are attached to the displays. In this way, the gluing is done faster, cleaner, and more economically.

Full-back Easels.—Full-back easels may often be used to advantage because they reinforce the cardboard, thus eliminating warpage and making it possible to use a lighterweight stock for the printing. Displays with full-back easels lie flat, so that they are easily packed for shipping.

To make a full-back easel, the easel stock is first cut to the same size as the printed display. The flap or wing, which is to be turned back to form the support, is then die-cut on the free side but is merely scored along the side which is to act as the hinge. A screen stencil is then pre-



FIG. 80.—Means of support for keeping displays in upright position.

pared, and glue is stenciled over the whole piece of material except the parts which are to serve as the wings. As the glued sheets are removed from the processing table, they are attached to the back of the displays. The displays are stacked one on top of another, so that their weight will cause the glued sheets to adhere more firmly to the displays.

Appliqué Letters.—Raised letters may be applied mechanically and accurately to a surface, thus avoiding any unevenness in spacing.

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First, the lettering is stenciled on a card of the desired thickness. This card is then die-cut, and the letters, instead of being stripped, are left in their original positions, being held in place by small links which are left uncut.

A stencil is then made of the lettering exactly as it is to appear, and glue is stenciled on the surface to which the raised letters are to be attached. The sheet containing the die-cut lettering is then mounted on the display on which the lettering is to appear. When dry, the die-cut sheet is merely lifted, leaving the cutout letters glued to the display in perfect position.

Slip Sheets.—All jobs should be slip-sheeted in order to prevent marring and scratching of the surface of the displays in handling. Fine onionskin paper, glassine paper, wax paper, or poster paper may be used for the slip sheets.

Shipping.—When displays are packed in shipping cases, even the slightest shifting within the cases is sufficient to cause broken edges and abrasions of the surface. If the contents do not fit snugly into the case, the free space should be stuffed with excelsior or paper. The shipping case may also be lined with waterproof tar paper as a protection against moisture.

When nailing up the box, the shipper should drive all nails straight into the wood. If nails protrude within the case, the contents may be damaged; if the nails protrude outside, they may cause physical injury to those who handle the boxes.

Metal straps or wire should also be nailed around the case in order to reinforce it.

If displays are to be shipped individually, they should be slip-sheeted and inserted in corrugated containers. These are made to order to fit any specified size. It is sometimes desirable to decorate shipping containers, as well as to stencil thereon a brief description of the nature of the contents and a simple panel or border for the label, giving the name and address of the manufacturer.

CHAPTER VIII

PREPARING DRAWINGS FOR SILK SCREEN PRINTING

The Layout.-In the preparation of commercial designs, it is frequently necessary for the artist to make sketches and "ideas" with extremely little information as to what the advertiser wants: the artist must simply proceed in the dark and try to produce a sketch which will stir the advertiser's imagination. In such a case, the artist can save much time if he first prepares a small layout of his idea in pencil, to give the client a general conception of how the artist thinks the subject should be treated. If the advertiser disapproves, no great loss of time is involved. On the other hand, if the layout is O.K'd, the next step is to make a miniature sketch in full color, or else to prepare a careful pencil sketch, reproduction size, painting the colors in only one corner or section of the sketch, so that the advertiser may be able to visualize the effect of the completed job. Tf the design contains much illustrative detail, the finished drawing should be made actual size in full color on a good grade of illustration board.

Size of the Drawing.—In nearly all cases, drawings for screen reproduction are made actual size. In some cases, however, small drawings are "blown up" on photostats or solar prints to the desired size, and the stencil maker works from such enlargements. This often saves a great deal of the time required by an artist to make a very large drawing.

Photostats and solar prints do not retain the true chromatic value of the colors of the original, however, and some of the delicate tones are lost. To remedy this, it is advisable to outline the colors in the original with a sharp, hard **pencil**, so that the boundaries of the various colors will be clearly shown in the print. Both solar and photostat prints are inclined to shrink unevenly in drying, thus causing more or less distortion which must be corrected before the stencil can be made. Very often a better plan is to make a clean tracing of the original on tracing paper, then have the photostat or solar enlargement made from this key tracing.

Lettering.—Whenever possible, small lettering should be simple in style and without serifs, in order to make the copy more readable and easier to reproduce. In display work it is advisable to avoid the use of very small lettering unless it is absolutely necessary.

If a large amount of very small copy must be reproduced, it is sometimes more economical to have it set in type by a printer than to have it lettered by hand. The printer's proof is then used as an overlay on the original.

Colors.—In screen printing, each tone and color requires a separate printing, except when transparent colors or photo stencils are used. If white appears in the design, the artist should count it as one of the colors to be printed, unless the printing is to be done on white stock. The planning of a color scheme which will keep the number of printings to the minimum is, therefore, one of the most important problems for the artist in screen work. Whenever possible, he must select colors which can serve a double purpose, such as making one color serve both for a flesh tone and for lettering.

In poster portrait work, faces should be painted in the fewest colors possible. The aim of the competent poster artist is to see, not how many, but how few colors or tones can be employed with success. This desirable simplicity reduces the cost of reproduction and makes for more forceful advertising and better poster art.

When mixing colors, the artist should be sure to make up a large enough quantity of each color to complete the drawing. This will make it unnecessary for him to stop painting so as to try to match colors after the drawing is under way.

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If there is any color left over, it will usually come in handy for spotting up and making corrections in the finished drawing.



FIG. 81.—Poster showing simple portrait treatment.

Where two colors meet, the dividing line should be very clearly defined. It is best to "cut in" one color over the other, so that the defining edge will be clean and sharp. If the outline is fuzzy and indefinite, the stencil maker will have to use his own judgment as to where the line should be. Such a decision should be part of the artist's responsibility. Drawings are sometimes made with transparent water colors, the tones being washed on flat; but most drawings for screen reproduction are made with opaque poster or



FIG. 82.—Effective modern poster treatment particularly well adapted for the screen process.

tempera colors. These should be applied evenly and just thick enough to secure opacity. If the paint is thick and lumpy, it will hamper the tracing during the process of stencil making. There are occasions when work must be turned over to the stencil maker before the artist has had an opportunity to paint in all the lettering. This does not handicap the stencil maker, provided the lettering has been sketched in on the original with pencil, but the practice should be avoided unless artist and stencil maker are able to work in close cooperation. A key outline of both design and lettering may be made to serve as the master copy for handmade stencils, if the color boundaries are indicated.

As far as circumstances permit, the design should be kept to the fewest elements possible, each one being made to count. Patches of lettering and illustrations scattered all over a display increase reproduction costs, weaken its artistic value, and make it less effective for advertising purposes.

A certain amount of shading may be simulated in screen printing by the use of stippling, crosshatched lines, tapered lines, and dry-brush work, but their use should be avoided unless the artist knows the limitations of the process. The distinguishing characteristic of screen printing is its flat, posterlike quality. It appears at its very best when used in printing designs which consist of broad simple masses. The artistic value of commercial work will therefore be enhanced by the avoidance of tricky effects and efforts to imitate other processes.

MAKING DRAWINGS FOR PHOTO STENCILS

The reproduction of fine pen drawings, Ben Day tints, wash drawings, and photographs by means of photo stencils brings to the artist new problems and responsibilities. Photo stencils are seldom made economically if they are merely employed as an afterthought. Plans for using them should be made at the time the drawing is prepared. This requires that the artist have more than a superficial knowledge of the process.

Since photo stencils are not so simple to make as other kinds, they are usually employed in combination with stencils of other types. For instance, the design to be reproduced may consist of large simple masses, except for



FIG. 83.—An effective poster treatment for theater lobby displays. The original poster was 40 by 60 inches and was printed in eight colors.

one small portion which may include small lettering or type, a trade-mark, or a reproduction of some product. The ordinary stencil methods will give a perfectly satisfactory reproduction of most of the design; therefore a photo stencil is needed only for those areas for which the ordinary methods are not suitable. Thus both types of stencils are frequently used in combination.

In the past, when it was desired to reproduce a piece of copy with a photo stencil, it was considered necessary to have a transparent positive photograph made from the copy. This assumption that the cost of making photographs was a necessary part of the expense in making photo stencils possibly accounts in part for the slight use made of them. The fact is that photographs are not needed for the reproduction of pen drawings, lettering, type, or Ben Day tints, if their use is properly planned in advance. It is necessary to have transparencies (photographic positives on glass, celluloid, or translucent paper) only when preparing a stencil from a wash drawing, photograph, or painting in color.

If the original drawing or lettering is made actual size on tracing paper, tracing cloth, traceoline paper, thin celluloid, or any other transparent surface, the photo stencil may be made directly from the original. Drawings may also be made on frosted glass, tracing paper, or celluloid with litho crayons, which appear almost like lithographs, when reproduced. Traceoline paper is preferred to celluloid by many artists because it is thinner and more flexible and holds ink better.

If celluloid is used, powdered magnesium should be dusted over it, then brushed off. This makes the ink or paint cling to the celluloid more firmly. Tempera drawings should be made with fresh colors, because paint which has often been diluted with water may lack the necessary binding ingredients to keep it from chipping off. The ink or paint must also be absolutely opaque in order to prevent the transmission of light. A good way to paint in solid masses is to outline the area with waterproof ink, then fill it in with red or black brushing lacquer. Lacquer thinner should be kept handy, to thin the lacquer and to clean the brush when the work is finished. Waterproof drawing ink is not a satisfactory medium to use when making drawings which are to be reproduced by means of photo stencils, because such drawings are seldom fully opaque, although they may appear to be very black when lying on the drawing board. A much better medium is photoengraver's opaquing ink.

If printed matter which is too small for hand stencil making is to be reproduced, a printer should be asked to set the copy in type and supply a good clean proof on cellophane instead of on paper. While the ink is still wet, it should be dusted with bronzing powder to make the printing opaque. This proof can be tipped on the original drawing for the approval of the customer, after which it is removed and used for the transparent copy in making the stencil. This same procedure should be followed when photo stencils are to be made from lettering, or from ink drawings. Instead of being incorporated with the rest of the design on drawing paper, they should be made on transparent material, and then temporarily tipped on the drawings with rubber cement.

Use of Shading Sheets.—Ben Day effects are secured by the use of Bourges, craftint, or para-tone shading sheets. First make an ink drawing of the subject on a transparent surface. Then cut a piece of the shading sheet to fit the area to be covered by the Ben Day, and mount it in place with celluloid cement or similar adhesive.

These shading sheets are supplied in over 150 different patterns and textures, and it is possible by using them, to secure a great variety of effects. When half-tone tints are used, it is advisable to use a fairly coarse half-tone screen, 40 to 60 lines to the inch, because if a finer screen is employed, the stencil is almost sure to clog unless the operator has had wide experience with this type of work. This same caution applies to the half-tone screens used on photographs.

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Screen Prints.—If a photograph or wash drawing is to be reproduced, it is first sent to a photoengraver, who makes a "screen print" from it. By this is meant a photograph (positive) which has been made behind a photoengraver's half-tone screen, which cuts the photograph into tiny dots. This screen print is not made on opaque paper. In order to be used in stencil making, it must be transparent, like a lantern slide. It is not necessary that the screen print be made the same size as the original: it may be made larger or smaller, as required. Because of their thickness, glass positives are not so suitable for stencil-making purposes as the positives made on celluloid or on translucent paper.

Color Work.—Except when transparent colors are used, other screen printing methods require a different stencil for each color or shade. By use of the photo method, however, the artist may plan his work so that three printings will give the effect of six or more colors. To illustrate: A reproduction is to contain yellow, blue, and green. Instead of printing the green as a separate color, the artist places a Ben Day tint on the drawings for both the yellow and blue stencils where the green should appear. When the prints are run off, the juxtaposition of the yellow and blue will produce the effect of green, just as it does in four-colorprocess printing.

Or, suppose it is desired to print two shades of red. By other stencil methods this would require two separate stencils and two printings. By the photo method, the artist makes his drawing in ink for the solid red, putting a Ben Day tint over the area to be covered by the lighter red. When the impressions are run off, both the lighter and deeper shades of red will be printed in one operation. For instance, if the drawing represents a girl with red hair, the lighter shade might be employed for the flesh tone and the deeper one for her hair.

The artist may be required to make a drawing for a booklet cover in several colors, to be printed from photo stencils. For this, he may proceed to make a key drawing in ink, exactly as if his work were to be reproduced by photoengraving methods. Drawings for the other colors are then traced in ink from the key drawing, solids and Ben Day tints being placed wherever required. If the other colors consist of very simple masses, the stencils for them may be either paper or film. Cross marks in ink should be made on the key drawing, and these marks must be traced on all the other drawings in order to secure proper registration when stencils for the various colors are made.

Another system which may be applied when ink drawings must be made from an original in colors is as follows: An ink drawing is made first for the color which fills the smallest area on the original, and a photo stencil is made from this ink drawing. The ink copy is again laid over the original, and this time the color which fills the next smallest area is inked in, and another photo stencil is made from that ink drawing. This process is repeated until stencils have been made for all the colors. They are printed in reverse order; that is, the first stencil made is the last one to be printed. It will be seen that, when the stencils are made in this manner, registration troubles are avoided because all the stencils are made from the same copy. The paint consumption is rather high with this method because one color is printed over another, as in the Selectasine method.

It should be borne in mind that, although the photo method makes possible the production of a great variety of effects which are not obtainable by ordinary stencil methods, one must not expect to produce the same results from photo stencils that are possible with four-color-process engravings. As stated in the opening chapter, the screen process has a place of increasing importance in the graphic arts, not because of its ability to imitate or supplant other processes, but because of natural virtues which enable it to do exceedingly well many things which other processes cannot do.

CHAPTER IX

ESTIMATING

No universally fixed scale of prices can safely be established to apply to the entire silk screen industry. The costs that determine the final selling price vary in different localities and may even fluctuate within a locality itself. Each job, therefore, must be considered individually and estimated individually. To quote a fair and acceptable price on a proposed job, the salesman must be well acquainted with operating costs, with production problems, as well as with other factors that form the basis of a reasonable estimate. In this chapter a general system of estimating is proposed that can serve as a guide and undergo modification to suit individual needs and conditions.

Variable Costs.—Recent attempts have been made to regulate prices within the law by establishing a fixed scale of wages. Organizations such as labor unions and employers' associations act in a measure to stabilize prices and combat the evils of cutthroat competition. Since labor unions are more likely to exist in large cities, labor costs in those areas are generally higher than in outlying districts.

There is also a great disparity in different sections of the country in the cost of rent, maintenance, insurance, taxes, shipping and trucking, and materials such as paint, stock, etc. Naturally, the selling price of a job will vary directly with the general costs; the higher the costs, the higher the price.

Competition.—In figuring a price, not only the tangible costs but also the more elusive factors, such as consideration of the law of supply and demand, are to be reckoned with. If, on a given job, competition is unusually keen, prices will generally be lower, although the operating costs remain the same. On a "first" job, representing the first time that the company has been called in for a bid for a prospective client, some salesmen are tempted to reduce the price somewhat in order to secure a new customer.

Contracts.—The price charged for contract work can, because it extends over a definite period of time, be lower than for individual jobs solicited in open competition. Work done on a long-contract basis can be produced more cheaply because production costs can be cut down considerably. Because of the experience and improved facilities for handling a certain kind of work, the margin of profit per job in a contracted series can afford to be lower.

Rush Orders.—A rush job is worthy of a higher price than the average job. Rush jobs frequently entail "timeand-a-half" labor costs to satisfy union regulations in regard to overtime work. It must also be remembered that work done hurriedly to meet a dead line may give rise to more spoilage and waste than normally paced production. The estimate given to the customer must make allowances for these factors.

Seasonal Work.—During the slow season of the year, there are those who feel that even a small margin of profit is better than none at all, certainly better than having the business at a standstill. As a general rule, it is better to retain the patronage of a large clientele that affords a steady turnover of business at a nominal profit than to limit the number of jobs by charging excessive prices.

Nature of Job.—A higher markup is necessary for printing displays advertising quality merchandise. A fine concern will expect and pay for quality printing to reflect the high caliber of its merchandise. Because of the extreme care required to produce perfect work, a poster proclaiming Tiffany's silver will cost more than one advertising a bargain sale.

All the variables listed demonstrate that the same order, figured by four different process shops in as many sections of the country, may show four varying estimates. Only experience and trade judgment will help the process man interpret his local conditions and determine the appropriate selling price.

| NO SALESMAN'S | INFORMATION DATE |
|---|---|
| SALESMAN REPORT | INDUSTRY |
| FIRM | OLD ACC'T NEW ACC'T CONTACTED BY TEL _PERSONAL CALL DIRECT ACC'T TRADE C.B WHEN WANTED SALE REJECTION |
| SUBJECT | DIE CUTTING SIZE OF DIE EASELING SINGLE DOUBLE SIZE OF EASEL BOARD BEVELING MOUNTING FLOCKING COLORS PACKED IN BULK INDIVIDUAL CONTAINERS#TO CONTAINER DELIVERY IN CITY OUT OF CITY PROOF WANTED |
| INDIVIDUAL COLOR3 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 | ROUGH SKETCH |
| REPORT APPROVED BY ESTIMATE NAILED DATE REMARKS | |

FIG. 84.—Type of salesman's information sheet.

ESTIMATING PROCEDURE

Collecting the Facts.—It is generally unwise to give an estimate based on a telephone description of the job. An estimate based on verbal information may be inadequate

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and may result in unpleasant complications. Not fully realizing the importance of every detail or fully understanding all the aspects of the job, the customer may, by his

| No | ESTINATE SHEET | | | Date | |
|---|--|-----------------|---------------------------|---|---|
| INDUSTRY FIRM Address Telephone Adv. Mgr Remarks | SALESMAN Old Acc't _ Contacted b Direct Acc' When Wanted | by Tel t Tra | COL Nem Per adie | COMMISSION New Acc't Personal Call C.B | |
| SCREEN PRINTING | QUANTITY | COST . | TOTAL | ACTUAL COST | _ |
| SURJECT ART WORK SIZE STCCK COLOR PT. BLEED MAKE READY PAINT VARNISE LABOR CREW HANDLING TRUCKING MOUNTING AND FINISHING NOUNTING AND FINISHING DIE DIE CUTTING EASEL SIZE CHIP JUTE EASELING PACKING CONTAINERS SHIPPING | | | | | |
| SPECIAL TREATMENT | | | | | = |
| BEVELING HAND WORK | | | | | |
| FLOCKING | | | | | _ |
| PROOF WANTED | | | | | - |
| TOTAL MFG. COST TOTAL MARK UP SELLING PRICE UNIT PRICE O.K'D. BY REMARKS | | | 1 | | |

FIG. 85.-Type of estimate sheet.

sketchy description, cause you to submit an unreasonable estimate. The best policy to follow in estimating is to make a personal call and look over the work to be reproduced. To prevent oversights in judgment, it is best for the salesman to use a printed form on which to jot down all the facts pertinent to the proposed job.

Salesman's Information Sheet.—This form can be inserted in a handy loose-leaf binder for ready reference. The salesman, with the original art work before him, fills in the points of information called for on the printed sheet. This will present a fair appraisal of the costs involved and will be the basis of the estimate (Fig. 84).

Estimate Sheet.—With all the specifications on the salesman's information sheet taken into consideration, the expected costs are filled in on the estimate sheet. This sheet then becomes a record of estimated costs from which the selling price is determined. In Fig. 85, note the column labeled "Cost." This lists the estimated costs of all that goes into production. The column headed "Actual Cost" is computed after the job is finished. Both these columns are then compared to see how close the estimate came to the actual cost. Any great difference between these two would indicate bad arithmetic or poor judgment somewhere along the line. Such a study will help iron out future estimating difficulties and is essential in cases where reruns are ordered.

Confirmation Sheet.—Most clients request a written confirmation of quotations to prevent misunderstandings, squabbles, and litigation. Instead of composing letters in essay form for each business transaction, a confirmation sheet (shown in Fig. 86) is mailed to the customer with the price and all other specifications indicated in an easy-toread manner. This sheet becomes an official document bearing the name of the vendor and the signature of the person in charge.

Figuring the Job.—Some firms make use of the following system in figuring jobs. They divide costs into (1) material costs, (2) labor costs, and (3) overhead costs.

Material costs include:

1. Stock: The surface on which the printing is done, such as cardboard, paper, glass, etc.
2. Printing medium: The material used to print with, such as paint, lacquer, dye, etc.

| $PRIN = \frac{43}{2}$ | 8-448 WEST 37TH STREET | NEW YORK CIT |
|-----------------------|--|--------------|
| PROCESS | ESTIKATE | PHONE |
| INCORPORATED | SILK SCREEN PROCESS REPRODUCTION | 7-9363 |
| 70 | المعيد ال | |
| 10 | | |
| | | |
| | | |
| SUBJECT | | |
| ÇUANTITY | | |
| ART WORK | BLEED | |
| SIZE | | |
| STOCK | · ······ | |
| COLORS | ······································ | |
| VARNISHING | | |
| DIE CUTTING | MOUNTING | |
| EASELING | | |
| SLIP SHEETING | | ····· |
| TO BE PACKED | | |
| UNION LABEL | | |
| WE CAN PRODUCE THIS | JOB IN DAYS | |
| TOTAL PRICE | (| |
| UNIT PRICE | | |
| KENARKS | | |
| | | |
| | | |

FIG. 86.—Type of estimate confirmation sheet.

3. Stencil-making medium: Material needed to prepare the stencil, such as film, block-out lacquer, glue, etc.

4. Finishing: This includes the die-cutter's charge for die-cutting, trimming, and easeling, etc.

5. Shipping: This includes the cost of special containers, shipping cases, and trucking, etc.

Fifteen per cent is added to the total material costs as a service or carrying charge for handling and possible waste, etc.

Labor costs include:

1. Art work: The cost of making preliminary sketches and finished art work, etc.

2. Color mixing: This charge is based on the time it takes to match and mix the required colors.

3. Make-ready: The cost of getting the screen ready, setting the guides, checking the register, and running proofs, etc.

4. Stencil making: This charge is based on the time it takes to prepare the stencil for each color.

5. Printing: This charge is based on the time it takes to print the entire job, to rack, and to wash the screens.

6. Handling: This charge is based on the time spent in collecting prints from the racks, in collating, and in preparation for shipping, etc.

7. Supervision: A charge for the production manager or foreman's time.

Fifty per cent is added to the total labor costs.

Overhead costs include:

1. Rent.

2. Utilities: telephone, electricity, etc.

3. Depreciation.

4. Incidentals: These include bookkeeping, insurance, dirt removal, taxes, bad debts, window cleaning, stationery, etc.

From the total monthly overhead costs, it is a simple matter to compute the overhead per working day. Figure out how many days it should take your shop to turn out the job, and include this overhead cost in your estimate. There is usually no markup on the overhead costs.

A hypothetical estimate is shown on the following page.

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| Material Costs | |
|-------------------------------------|--------|
| \$1000, plus 15 per cent | \$1150 |
| Labor Costs | |
| \$1000, plus 50 per cent | 1500 |
| Overhead | |
| \$20 per day (8 days) | 160 |
| | \$2810 |
| Salesman's Commission (10 per cent) | 281 |
| Selling Price | \$3091 |

CHAPTER X

SHOP MANAGEMENT

Inasmuch as commercial silk screen shops usually operate on a competitive basis, the shop manager who would run a successful business must give close attention to all production details. The elimination of minor wastes in time and material often spells the difference between "breaking even" and showing a profit, whereas inefficient shop practices under poor management are often the cause of losses at the end of what has seemed to be a busy season.

When the salesman brings in a new job, the production manager should consider every phase of the work to be done and try to visualize the attendant problems. After he assigns the preparation of the stencils to the stencil department, the production man should check up on his stock of paint, paper, and other supplies, so that orders may be placed for the needed material in time for it to be on hand when printing operations are scheduled to begin. Frequently stock must be ordered well in advance; this is especially true of paper of odd sizes and weights.

The wide-awake manager will so arrange his production schedule, his equipment, and distribution of work as to eliminate all "bottlenecks" in the production process, so that each job may flow uninterruptedly through the plant at an even, steady pace. The foreman or manager should assign a *specific* job to each man and see that it is done satisfactorily. Failing to check on the work results in a lack of shop discipline and a consequent lowering of production efficiency.

A wise distribution of work is the basis of good organization. When the job is turned over to the squeegee man, paints should already be matched, mixed, and proofed; a make-ready prepared; and a few copies printed for It is a waste of time to assemble the printing checking. crew and make them wait around while this preparation is being made. Often, in elaborate jobs, make-ready and proofing may take considerable time before the "O.K." can be given to go ahead with the printing. There is nothing that kills efficiency as much as to see men "hanging around" with folded arms because they have been called long before the work was ready for them. There's always some related productive work to be done, and it is the shop manager's job to anticipate every exigency. A two-man crew for each printing table is usually sufficient. Hiring more "help" than is essential impedes efficiency. On the other hand, it is perverted economy to try to save money when there is an obvious need for more men.

Men should be cautioned against smoking while at work. This is especially important for those whose work calls for repeated manual motions such as are required in squeegeeing and racking. The nature of such work does not permit the leisurely demeanor of the habitual smoker. Puffing on a cigarette, then carefully balancing it on the edge of the table to keep an eye on it, and removing the ashes with the air of a country squire are definitely out of place in a busy shop. Not only does smoking slow up production, but smoking in the proximity of paint, kerosene, and other inflammable materials presents a fire hazard that should not be tolerated.

The following suggested improvements in shop equipment, although they do not exhaust all possible production aids, will nevertheless be found helpful.

1. Rolling Tool Table.—A rolling tool table equipped with casters so that it can be rolled easily about the shop will be found indispensable. This table should have a complete assortment of nails, screws, hinges, etc., as well as hammers, screw drivers and other equipment that might be used for hinging frames, fastening guides, and general make-ready work. 2. Rolling Proof-paper "Horse."—This is a wooden "horse" equipped with rolling casters, on which is attached a dispenser for a roll of newsprint paper. A large roll of white newsprint paper is inexpensive and is ideal for proof printing. The paper can be cut off at any length and takes a clean impression (Fig. 87).

3. Paint Inventory.—The production manager should have at his disposal paint catalogues, specimen booklets, and samples of material. He should keep this data organized, up-to-date, and easily accessible for reference



FIG. 87.—Rolling proof-paper "horse."

when he is ordering materials and supplies. A constant inventory of the paints on hand may be maintained by employing some system similar to that shown in Fig. 88. Samples of each color are stenciled on index cards. The manufacturer's name or the number of the color and the quantity of each particular color in stock may also be indicated. To make this inventory really helpful, every withdrawal from or addition to any color should be noted on the respective color card. The exact quantity of each color will thus always be shown on the inventory chart. This system of color index cards not only serves as an inventory but is equally useful in matching colors from art work for reproduction. The color card is removed from the sliding rail and is laid alongside the color on the art work that is to be matched. Even if the closest stock color does not exactly match the shade, it can certainly form the base for the desired shade.

4. Stalls for Frames and Squeegees.—Racks or stalls should be constructed for storing stencils. The racks should be so built that the frames can be kept upright and any frame slipped out without disturbing the others.



FIG. 88.—Type of color inventory chart.

The frames may be painted in various colors to serve as a key for recognizing at a glance the kind of silk each one holds. For instance, frames with No. 8 silk may be painted brown; with No. 10, green; with No. 12, blue; with No. 16, red; etc. For finely detailed printing the red frame would be taken, with the assurance that the silk is good enough for fine reproduction work. Labels indicating the name of the job should be pasted on those used screens that are being held in abeyance for a possible reorder. Some stalls may be constructed to occupy a fixed position off the floor so as not to take up valuable working space. Other rack units may be equipped with casters to be easily accessible and yet not troublesome to move around. Each squeegee should have a definite position on a storage rack. The length of the squeegee should be marked on the squeegee itself as well as on its corresponding place on the rack.

5. Color-testing Screen.—To get the true value of any color that is to be matched, paint should be printed through a small screen especially devoted to testing. All colors should be pretested before the run.

FIG. 89.—Use of clamps and front hinge.

6. Printing Frame Clamps.—Clamps such as those shown in Fig. 89 will be found preferable to screws in attaching the hinge to the printing frame. The frames are then easily engaged or removed and can readily be shifted and clamped to a fixed position on the printing bed. The hinge shown in the foreground of this diagram is an ordinary brass hinge with the pin removed, attached to both the frame and the printing base. It prevents any possible side-to-side shifting of screen during the printing operation and is an aid to accuracy in color registration. Of course, when special metal printing units are used, this arrangement is unnecessary.

It is generally advisable to make all possible fixtures and units mobile, so that all required equipment can be moved easily to any part of the shop when needed.

CHAPTER XI

RECENT DEVELOPMENTS

This chapter will deal with improvements and new developments in screen process printing in the last few years. Some of these were considered in the earlier chapters of this book as new attempts and have only recently proved their practical value. These developments have simplified the procedure and improved the quality of silk screen printing.

IMPROVEMENT IN SCREEN MAKING

A. Handmade Stencils.—The advent of hand-cut film stencils has virtually revolutionized the methods of stencil making. The use of Nufilm and Profilm makes it possible to reproduce work of fine character and detail. Formerly Profilm was prepared in such a way that it required the use of a hot iron for the adhesive process. Profilm can be had today that is adhered like Nufilm with lacquer thinner. The film method is described in detail on page 103.

Recently the Nufilm Company has introduced Blufilm, which has several additional advantages over Nufilm. Its neutral blue color eliminates confusing color distortion, thus making it easier to distinguish colors of the original art work. It is less glossy than the Nufilm and thus helps eliminate eyestrain. The knife cut seems to show up better on this type of film, and that makes it especially convenient for cutting fine detail.

B. Photo Screens. 1. Four-color Process.—Fine silk screen printing is now done on a photomechanical basis. This enables a progressive process house to handle four-color process reproduction for display purposes in short

runs. The results are comparable to those of lithography, yet the costs of plates, make-ready, etc., are considerably lower. It is possible to work from any color copy generally used in the graphic arts: Kodachromes, carbro prints, or original art work in full color.

The new methods in silk screen printing do not attempt to compete with the lithographer for long runs but fill the gap that has until now been present in short-run work. This is especially true in sizes of from 11 by 14 to 40 by 60 inches. From the standpoint of cost, runs of from 100 to 1000 pieces can be printed on an economical basis. In small sizes up to 11 by 14 inches, from 100- to 133-line half-tone screens are used. An 85-line screen is used on the larger sizes between 22 by 28 and 30 by 40 inches. On still larger sizes up to 40 by 60 inches, about a 65-line screen is used.

The development in this sphere of photographic work has widened the scope and extended the market of silk screen work. This four-color process makes it possible for the smaller advertiser to put out display material in beautiful color that heretofore only large-scale advertisers could afford to buy. Expensive cameras, elaborate equipment, and a thorough knowledge of color separation and photography are the requisites for successfully handling four-color process work. This is as yet somewhat beyond the scope of the average screen process shop.

2. Daylight Transfer Film.—There are several excellent photographic films on the market that require very little extra equipment. This photo method does not require a camera, darkroom, or special photographic knowledge. The Super Duro, the Photoetch, and the Photox film come ready to use, and the procedure for their use is more or less the same. It is a good policy to buy a trial sheet for the initial experiment. Full instructions for use will be sent with the trial order. This method is good for half tones, fine lettering, detailed facsimiles, etc. If properly prepared, the stencil will last for thousands of impressions. It is a good method with most printing mediums except tempera colors.

This is, in essence, the general procedure:

It is best to use a fine grade of Swiss bolting cloth with a No. 16 or No. 18 mesh. Clean the silk with hot water and a sponge. Using a small scouring brush and cold water, rub all filler and foreign matter out of the screen, rinse the screen well, and allow it to dry naturally.

Sensitizing the Film.—The entire operation of sensitizing the film may be done in daylight or in subdued artificial light. Cut a piece of film at least 1 inch larger all around than the actual size of the art work. Using Scotch tape, fasten the film onto a flat cardboard or glass, with the emulsion side up, as shown in (1), Fig. 90. To determine the emulsion side, wet both middle finger and thumb, and press the film between these two fingers. The sticky side is the one with the emulsion. Use the sensitizer that comes with the film, and follow the simple directions on the label or instruction sheet to mix the solution. It is best to prepare fresh sensitizer each time it is required, especially during the summer months. In the winter, the mixed solution may be kept in a dark-brown glass bottle for a week or so without spoiling. To sensitize the film, pour some sensitizing solution into a glass or porcelain dish. Take a flat camel's-hair or other soft-hair brush, about 2 or 3 inches wide, and evenly coat the film in both directions, as shown in (2), Fig. 90. Apply liberally, and avoid "holidays." Make sure that there are no puddles or surplus accumulations in one spot. Allow the sensitized film to dry with the aid of an electric fan.

When thoroughly dry (in about 10 to 20 minutes), it will be ready for exposure. Remove the masking tape, and release the film. Although this film is not highly sensitive to daylight, it is better to keep it in a dark place until ready for exposure.

Contact Setup.—An ordinary photographer's printing frame or a vacuum printing frame can be used for maintain-

ing firm contact between the film and the copy. If such a frame is not available, use the following method. Place a



FIG. 90.—Steps in making a daylight transfer film stencil.

sheet of plate glass on a level table. Over the glass place a piece of black felt or black sponge-rubber mat. Lay the sensitized film on the pad with the emulsion side facing down. On top of this, place the positive or transparency face downward. On top of all this, place a second sheet of heavy plate glass. The setup, as shown in (3), Fig. 90, is now ready for exposure.

Exposure.—The source of light for exposure may be sunlight, carbon arc lamp, or photoflood bulb No. 2. Artificial light is preferred because it can be controlled and measured. Keep the lamp at a minimum distance of 12 inches from the copy. The length of exposure time is governed by various conditions: the distance of the light to the film, the intensity and nature of the light, the degree of transparency of the positive, the nature of the drawing, etc.

Since no exposure chart can be fixed, some experimenting should be done to determine the length of exposure. A clear transparent positive takes about one-third less time than a drawing made on tracing paper with an opaque medium. Exposing time may vary as much as from 2 to 12 minutes.

Washing the Image.—After exposure, remove the film from the contact setup, and place it, as shown in (5), Fig. 90, in a porcelain or glass tray containing hot water of no more than 120°F. Submerge the film with the emulsion side downward. In a few minutes the image of the copy will begin to wash away from the film, discoloring the water. Lift the film out of the water, and submerge it again with the emulsion side up. To hasten development, agitate the water a little. When development is complete, place the film on a black cardboard or glass, with the emulsion side up, and spray it gently with cold water [(6), Fig. 90]. This process will wash off loose particles and harden the gelatin. The film is now ready to be adhered to the silk screen.

Adhering the Film.—Cut a cardboard build-up slightly smaller than the screen itself, and lay the wet film on it with the emulsion side up. The build-up will assure good contact between the silk of the screen and the emulsion on the film. Place the silk screen over the film, and blot the silk with newspaper, replacing wet paper with fresh sheets until all excess moisture has been absorbed [(7), Fig. 90]. This process impregnates the emulsion of the film into the silk. Use an electric fan to dry the film thoroughly.

Removing the Film Support.—When the film is dry, the backing sheet is peeled off, leaving the emulsion of the film adhered to the silk [(8), Fig. 90]. The screen is now ready for printing.

Cleaning the Screen.—When the job has been printed and no reruns are expected, remove all paint from the screen with the proper solvent. Then wash the screen in hot water mixed with 5 per cent ammonia water. Rinse the silk clean with a sponge and cold water.

C. Stippling and Special Effects.—Although the film-cut stencils and the photographic stencils comprise the basic methods in commercial use today, much interesting work of a semicommercial and fine-art nature is done with tusche stencils. At a recent gallery exhibit demonstrating the silk screen process as a fine art medium, the tusche method was practically the only stencil method employed. The fine reception given to this exhibit by the critics testifies to the merit of this method of stencil making for certain types of work. Tusche may be used in stick or liquid form or in dry-brush technique. A grease or wax pencil may also be used. Each technique will yield a different effect. Halftone effects may be simulated by rubbing wax or tusche crayon on a silk screen that is in direct contact with Ross board or sandpaper.

Surprisingly effective results are thus attained by trained artisans. Tusche may also be spattered on the screen, although this method is a little difficult to control. For stipple work, in conjunction with film cutting, a simple wood-burning tool can be put to use. This must be deftly applied to the film, since each application results in a small dot. This procedure is easier than knife-cutting an infinite number of tiny dots by hand.

IMPROVEMENTS IN EQUIPMENT

Power-driven Machines.—Printing machines have been used in silk screen work for a number of years. It was not until recently, however, that they were so perfected that they successfully print as many as 2000 impressions per hour without the smearing of prints or delays in makeready. In fact, the machines now produce cleaner prints than the hand squeegee, since the momentary contact of silk and printing surface prevents slurring or dragging of the silk on a wet print.

The manufacturers of the Selectasine process press have made many late improvements in feeding devices that make their machine practical for many types of work. This machine is good for printing on thin cardboard, decal paper, and many other materials that are completely or slightly flexible. Not only does the press produce the work more speedily than manual squeegeeing, but its use in large-quantity production makes possible a substantial saving in paint consumption. This is due to the linecontact principle upon which the machine is constructed. The squeegee, the printing surface, and the segment of the cylinder are in contact only for an instant, and this eliminates any excessive paint absorption through the silk. The thickness of the layer of paint can be regulated by adjusting the pressure of the squeegee.

The make-ready for the latest models is simple, and it does not take long to get the press in full swing. It is ideal for certain types of long-run jobs and, in such a capacity, will make up its initial cost in speedier printing and in low paint consumption.

It is, however, subject to certain limitations. Its use is limited to flexible surfaces. It is a cylinder press and cannot be used on unyielding surfaces such as glass, heavy metal, or wood. It is also limited in the size of the printing surface. A handmade screen can naturally be tailor made to fit any unusually large size. The Selectasine press takes a maximum printing surface of 32 by 45 inches.

The new Johnston press is a flat-bed printing press. This makes it possible to print any flat stock, from Cellophane to metal or glass. It can turn out from 750 to 1000 impressions per hour. Various fine micrometer adjustments on the press assure good registration. The stock to be printed is held in place by guides that disappear below the surface as the screen contacts the vacuum printing bed. The printing area is limited to 32 by 46 inches. Companies selling silk screen presses cooperate in designing and setting up appropriate drying and racking facilities.

IMPROVEMENT IN SUPPLIES

The laboratories of paint manufacturers are constantly perfecting paints, varnishes, etc. Improved flexible colors are obtainable for printing on oilcloth and other such flexible materials. A crystal-clear base has been developed to reduce the thickness of the printed coat of paint and to make colors exceptionally transparent. This is especially desirable for printing with photostencils. This crystalclear base should be used in conjunction with the color "toner" and "reducer" made by the same manufacturer. Improved enamel paints are to be had from leading paint manufacturers for printing on metal to be kiln baked.

Flock manufacturers will mail, upon request, catalogues of new shades and grades of flock material for silk screen work. These come in brilliant or pastel colors and in silk, rayon, wool, or cotton. A special paint that can be printed by silk screen is available as an adhesive base for the flock material. Air guns are used to spray the flock dust, and electric vibrators are used for distributing the flock smoothly on the surface.

OTHER DEVELOPMENTS

Not only has the silk screen field advanced technically; there has been advancement in another sphere. The recent trend to organize its various elements has given this graphic art its proper place among recognized printing crafts.

The silk screen industry in New York has become affiliated with the Sign and Display Union. In agreement with employers and workers in this field, the union has standardized wages according to the various skills. A movement to organize the silk screen craftsmen on a national basis is well under way. In larger cities organizations of shop owners function to discuss prices, trends, and problems of mutual interest.

Silk screen "clinics" are frequently held that are open to the people in the trade and to the general public. These meetings, sponsored by manufacturers of silk screen supplies, feature addresses by experts in the various phases of this work. The latest developments are demonstrated; questions and problems are answered.

Silk screen exhibits of a commercial and fine-art nature are held in metropolitan areas. Such exhibitions are both inspiring and instructive and are received enthusiastically by the press and the public. A collection of pictures adequately demonstrating the use of silk screen as a fineart medium has been received by art critics who eloquently expressed their appreciation in art journals and newspapers. Courses in silk screen work are given in a number of public day and evening schools. These courses are planned for students, artists, and apprentices. An intensive course in silk screen is given in the School of Industrial Art in New York.

All these recent developments have helped to widen the scope and narrow the limitations of this important, versatile graphic art.

REFERENCE

The Signs of the Times has a monthly section devoted to silk screen news, developments, and advertisements, which will be found very helpful. It is a reputable source of information for names and addresses of local dealers.

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