day. These elements are always uncertain but can be minimized by special training and selection of personnel, but they cannot be disregarded.

The results of these tests are not startling, and some of our original questions remain unanswered. However, we have proven to our own satisfaction that the methods employed were sound and the desired accuracy was achieved. Also, as an important by-product, our knowledge has been broadened sufficiently to open new avenues for solving similar problems.

Plastic Scribing

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ABSTRACT: *The following paper is a brief description of scribing as applied in the preparation and reproduction of maps and charts in the Photogrammetry Division of the Coast and Geodetic Survey. Because of the widespread interest in this relatively new craft which has replaced drafting in the last few years, this paper is intended to give the reader a useful knowledge of the technique and its possibilities.*

IN THE last few years most Government Agencies engaged in mapping have made considerable progress in scribing on plastics in preparing final copy for photolithographic reproduction in the printing of maps and charts. The term "scribing" as applied here defines the selective removal of a coating on a plastic base with a pointed instrument, a method similar to engraving on glass.

Map information formerly drawn laboriously in opaque ink on a white background is now much more easily scribed as clear transparent lines or symbols on an actinically opaque background by means of a variety of special instruments and guides. The resulting negative may be used in the same manner as a photographic negative for subsequent reproduction processes.

For the reproduction of charts, the Coast and Geodetic Survey has employed some form of glass engraving successfully since the beginning of the century. Full utilization of this advantageous method came about with the development of special scribing tools and coatings, and later the advent of dimensionally stable plastics, a primary requirement in cartography. Certain color separations of maps had been scribed on plastics for reproduction by the Coast and Geodetic Survey Reproduction Branch by 1946 and though successful, scribing was not continued further until a few years later. By 1951 several mapping agencies conducted tests of their own with plastics and coatings and obtained good results.

The Photogrammetry Division in the Coast and Geodetic Survey is a supporting unit for nautical and aeronautical charts, as explained in accompanying papers of this series. Large scale maps and plans are produced to aid in the construction and maintenance of charts, reproduced and printed in color and in quantity for public issue. The supporting photogrammetric surveys are reproduced in one color only and are filed in the Bureau Archives as permanent records. Copies of these (usually ozalid prints) are issued at cost to the public and to other Government agencies upon request. Consequently, manuscripts are first compiled as rough drawings, then smooth drafted or scribed for acceptable reproduction of the file copy. This preparation of the final reproduction medium was accomplished by pen and ink drafting on metal-mounted paper until 1952 when, with the assistance of the Reproduction Branch of the Bureau, the Photogrammetry Division adopted scribing.

In addition to scribing for reproduction in one color only, the Division also compiles and scribes the land information in

the construction and revision of some nautical charts, and does color separation scribing of topographic quadrangles on a reimbursable basis. Gratifying results were obtained immediately upon adopting scribing techniques. Experienced pen and ink draftsmen required only a few days practice to acquire the proper touch for adequate scribing. Less experienced personnel required somewhat more time, but in every case the method was easier than drafting and produced better results. New employees could be trained in only a fraction of the time required to do acceptable pen and ink drafting.

The scribing method was readily applied in the three photogrammetric field offices as well as the Washington Office. Scribing in the three field offices has been so satisfactory that they now usually scribe the final copy of each map before forwarding it to Washington. The Division has also recently installed contact printing equipment (vacuum frame, arc lights, and developing tanks) in each of the three field offices to facilitate the processing of "guide images" (copies of map manuscripts) from the compiled manuscript onto the scribed sheet and the preparation of copies of scribed maps as needed.

Scribe Coatings

An important necessity for successful scribing is a good scribe coating. To meet a group of somewhat conflicting demands, much research went into the development of this requirement. It is desirable to have a coating sufficiently transparent to observe and to follow copy placed under it on a light table, yet it must be sufficiently opaque to prevent the penetration of those wave lengths of light which affect the photo sensitive emulsions used in printing. It should resist mutilation in normal handling, yet enable the smooth and clean removal of intricate and sometimes congested detailing with the proper instrument. It must be receptive to water-sensitizer for economical and efficient processing of guide images, and at the same time be safe for the possible use of solvents in photo mechanical etching or selective removal by hand. The coating should also permit additional detailing or notations in pencil and ink.

All these requirements have been met in the scribe-coated sheets made available to the Photogrammetry Division. Flopaque paint was used in the first successful coating on plastic in our reproduction branch. This coating is still satisfactory and in use today. Scribe coatings are prepared in a vertical whirler. Coatings may also be applied by roller coating, spraying, or screening, and good scribe coated sheets are available commercially.

A guide image is normally processed by the "Watercote" method. This requires a minimum of equipment and material and is easily accomplished in our field offices. Watercote is a commercial product and available in several colors. This sensitizer is applied to the coated sheet by swabbing, flowing, whirling or rolling, whichever is most convenient. After it dries it is placed in the vacumn frame in contact with the manuscript, or the negative of a manuscript, and exposed to intense light. After the proper time exposure, the sheet is flushed with ammoniated water. Next, it is rinsed in clear water and, if necessary, is swabbed lightly with a soft material to assure a clear image of all detailing to be scribed. The sheet is then removed from the water and, after it has dried, it is ready for scribing. Guide images in combinations of colors may be obtained by successive exposures and developments where this is desirable because of source material variations, or where distinctive clarification of detailing is required.

Instruments

Basic tools originally employed in engraving on glass were used in scribing on plastics with equally good results, and they have remained very much the same. The three most important instruments used for nearly all detailing are illustrated.

The first instrument (Figure 1) is commonly referred to as a "rigid scriber," which is the most widely used tool. Preferably made entirely of metal, it is used for scribing single lines up to 0.012 inch in width. The chuck is tooled to receive a good grade phonograph needle. Two basic sharpening operations are required for successful scribing. First the needle is inserted in the chuckpin (Figure 1a) and, by rotating the pin and needle through the channel of the block placed on top of an Arkansas oil stone, an angle of 51 degrees from the horizontal mounted position is obtained. Second, the needle is then fixed in the

scriber, the scriber placed on the oil stone and, by careful rotation, a flat surface is formed at the tip of the needle. The diameter of this surface should be equal to the desired width of line to be ascribed. A special type of Philco Long Life needle with offset point for line widths to 0.006 inch has also been in use successfully. Only the second step for controlled sharpening of this needle is possible, but it is adequate. The harder metal at the tip of this needle requires less-frequent retouching. This instrument may be used freehand for the execution of detailing single lines, or in conjunction with a straight edge, curve or templet with various symbols. Broken lines are usually scribed as solid lines, and are then opaqued at the required intervals with Turquoise Prismacolor pencil or opaquing fluid.

The second instrument two is the "swivel scriber." It is made to receive a blade of a hard steel for scribing single lines in excess of 0.012 inch or for multiple lines, such as roads, bar scales, etc. As the name implies, this instrument permits a swivel action for scribing curved, parallel lines or, by using it against a straightedge, for straight, multiple lines. The adjustable magnifying glass with lock nut enables good vision for close adherence to guide line. Cutting blades are pretooled for the desired nib and sharpened at the cutting edge in a special device illustrated in Figure 2a. A 51-degree angle in the direction of the cut, and a meeting angle of 5 degrees from the rear,—both as viewed from the mounted position when ready for use—are obtained with the sharpening device on an oil stone. The direction of cutting is confined to a pulling (backward) motion only.

The pen-type scriber (Figure 3) is provided with an angular chuck to permit the inserted needle to be in a near-vertical position if the penstaff is held in a normal manner. It is used for retouching and for scribing fine lines, such as close contour intervals. The scribing point should not be prepared as rigidly as the one used in the rigid scriber. The freehand action of this instrument requires that the edge around the flat surface area at the tip of the needle be rounded off slightly. This scriber may also be used in conjunction with a straightedge, curve or symbol templet.

Other scribing instruments are in use—too numerous to illustrate. Each one is designed for a specific function. The "building graver," for example, is very useful in the delineation of standard size buildings. Several designs are in existence. The most simple is the conversion of the round-tip needle in the rigid scriber to a needle with a chisel-type cutting point. The width of the chisel edge corresponds to the required width of the building symbol, the length is controlled by using it with a templet in a fixed position. This templet may be adjustable so that it can be used for other similar operations. Another instrument of note is the dotting implement, which may be one of several designs operated mechanically or electrically. One hand-operated tool, designed on the principal of the ratchet screw driver, has given good results if it is operated with due care. The rotating point is a phonograph needle sharpened to a chisel-type edge with bevel to resemble the face of a drill. Operated in a vertical position, it removes the coating by its rotating action and produces a dot.

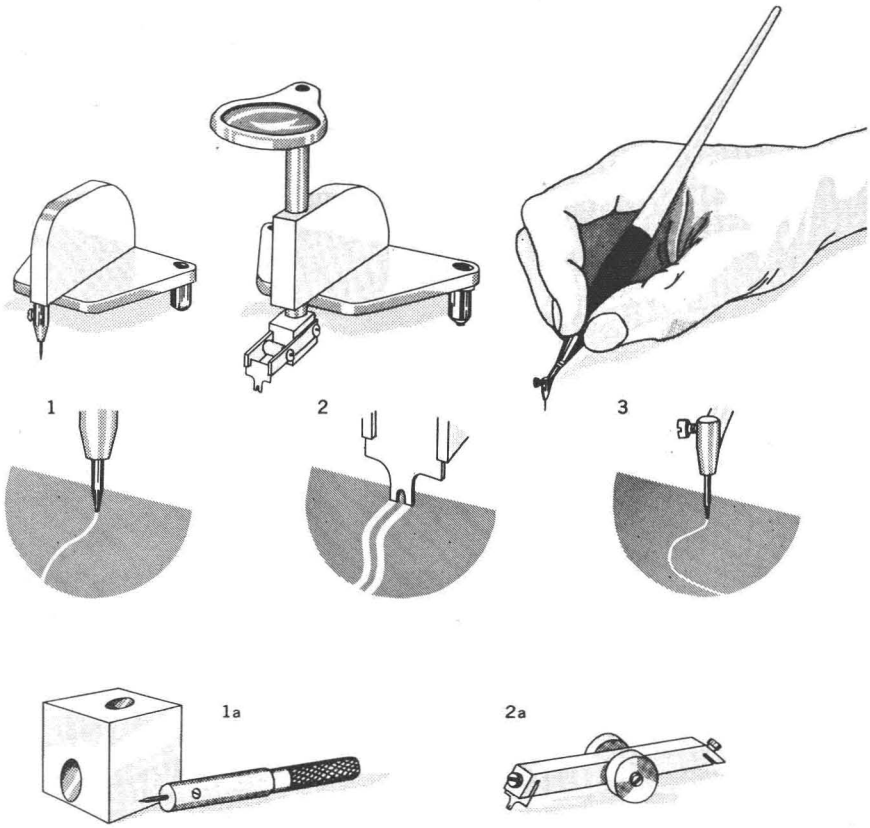
Careful shaping of the scribing points and the elimination of the slightest imperfections are necessary for satisfactory operation. Only properly sharpened needles and blades in appropriate instrument enable good results and the complete satisfaction of the scriber.

The above mentioned instruments are available from several manufacturers.

Light Table

Successful scribing on opaque-coated sheets requires a glass-top table with adequate lighting underneath. The light tables in present use measure 42 by 60 inches and are adjustable in height between 30 to 36 inches. The glass top is 30 by 48 inches, and is illuminated by four 40-watt, 48-inch, fluorescent tubes mounted in a concave, white-coated, ventilated chamber. The light is controlled by two switches, each for two staggered lights. For some kinds of work, a smaller light source would be adequate.

Additional items required for complete scribing operations are: a "linescope" (a 40-power shop microscope containing one-thousandth-inch graduations) for verifying the width and sharpness of lines; a magnifying glass (reading or jeweler type) for free-hand scribing in congested areas; opaquing fluid or prismacolor-type pencil for opaquing fine lines; grease pencils for



FIGS. 1, 1a, 2, 2a, and 3. The three principal instruments used in scribing map detail on coated plastics.

covering blemishes on the scribe-coated sheets; templets of symbols on clear material or thin metal as required; straightedges, and curves.

PROCEDURE

For color-separation scribing, a separate "guide image" sheet is needed for each color represented on the published map. Using common registration marks, the scribing of the detail applicable to each color is accomplished with the appropriate instrument by cutting along the guide line. Proper pressure, depending on the weight of the line, should result in the removal of the coating to represent a clean, uniform and sharply-defined line.

Our present practice is to limit scribing to line work, that is, to the same details that were formerly drawn with pen and ink, whereas the names and symbols are applied by the "stickup" method. A contact positive of the scribed sheet is produced either by photography or lithography from the scribed negative, and the stickup is added to this positive copy. A contact film negative is then made from the composite positive for further reproduction processes. This final negative is used to prepare a printing plate for photolithographic printing, or a film positive for the production of ozalid prints, or for contact-print paper positives in limited quantity.

Other methods might be used for the application of lettering and symbols, such as follows:

(1) Type and symbols with adhesive backing may be applied to a clear plastic sheet keyed to the scribed sheet. This overlay could then be processed onto the scribed sheet by photo-mechanical etching,

or a separate negative could be made for the additional exposure to the proper printing plate.

(2) Lettering and symbols may also be applied directly to the scribed negative with stripper film. This requires the removal of the coating in the selected areas where the stripper film is to be inserted. This method is not applicable where the areas of symbols are very extensive.

Solid Tints

For solid tints, halftone screening, or vegetation symbolization in photolithographic reproduction, either a negative or a positive may be prepared, depending on the relative area involved. As the final reproduction medium required for the exposure on the appropriate printing plate is in the form of a negative, a negative copy must be made if the work is prepared in positive form.

Factors Affecting the Selection of a Positive or a Negative

For small areas of tint, screening or vegetation, a positive copy may be prepared by placing a clear overlay over the scribed sheet, adding the required registration marks and opaquing the affected areas. The selective removal of the coating of clearly outlined areas and scribing the desired registration marks would result in a negative. For affected areas in excess of 50 per cent of the limits of the chart, the preparation of negative copy is more economical. On the clear overlay placed over the scribed sheet, the unaffected areas (in addition to a safe border outside the limit lines) are opaqued, thereby leaving all affected areas clear and producing a negative. In the removal of the coating of affected areas to produce a negative, the unaffected areas may be protected by a solvent-resistant opaque coating and the balance removed with the proper solvent.

The resulting final negative is used for solid tints; however, in the case of screening or vegetation symbol must be combined with a master negative of such screening or other symbolization in the preparation of the printing plate.

Advantages

Important advantages have been realized in the period of over four years since scribing replaced drafting in the Photogrammetry Division.

a) *Production Increase.* As scribing is more rapid than drafting, there has been an increase in excess of 75 per cent in the production of charts and maps.

b) *Quality.* Scribing results are more uniform and are of better quality than was ever possible in pen and ink drawing. The former step of opaque detailing against a clean background for desired contrast required more of the lithographers' time for painting and retouching.

c) *Training.* As stated previously, the training period of new employees for scribing has been reduced considerably.

d) *Flexibility.* Handling and storage is less of a problem. Scribed plastic sheets are more responsive to variable demands in photo-lithography. Thin plastics enable contact printing from either side, for example, much like photographic films. Recent coatings have been made very translucent —yet actinically opaque—permitting scribing by tracing without a light-table.

Disadvantages

Difficulties encountered in making extensive revisions on the scribed plastic sheets have not been completely resolved. Most of the Bureau's nautical charts, subject to frequent revision and reissue, are maintained on glass negatives. These permit revision to any extent very readily. One phase of the work of the Photogrammetry Division involves the correction of revision of land details on nautical charts by direct application from photographs to the chart drawing. The revised detailing is transferred and engraved on the glass negatives by the Reproduction Branch. Considerable savings could be effected if such revisions could be applied directly to plastic negatives by scribing, and effort is being devoted to this problem.

A scribe coating on thin film with adhesive backing has been made available recently which may solve this problem partly. This requires the removal of the original coating of the affected area to receive this new coating by burnishing. Another method is to paint out on the scribed negative the areas to be revised, and to produce a duplicate negative on a scribe coated plastic sheet for completion.

SUMMARY

In the reproduction of charts and maps, scribing is relatively new and its potentials are not fully explored. However, much progress has been made within a few years in the craft of scribing. Because additional instruments and materials are expected to be available, further progress may be made in the future. One factor, above all, has been very satisfying: anyone associated with scribing has found the effort very rewarding and the quality of the product better than anticipated.

An Inter-Agency Committee on Negative Scribing was organized in March, 1954 for an advantageous exchange of information. This committee, made up of representatives of several Government mapping agencies, has contributed considerably to the remarkable success in scribing. A similar group of representatives is in the process of preparing an extensive Scribing Report at the direction of the Bureau of the Budget. It is expected that this publication will be available soon.

New Maps of Liberia

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THE Republic of Liberia lies on the southwest corner of the great bulge of the African continent. Its area of about 38,000 square miles is bounded by Sierra Leone on the west, French Guinea on the north, Ivory Coast on the east, and about 375 miles of the Atlantic Ocean on the south. Liberia lies entirely within the torrid zone; its most southern extremity, Cape Palmas, is less than 325 miles from the equator.

A joint agreement for technical cooperation relative to mapping was signed by the Government of Liberia and the United States in December 1950.

As one of its programs under this agreement, the U.S. International Cooperation Administration was to provide advisory and technical assistance in establishing the Liberian Cartographic Service. ICA obtained the services of the Coast and Geodetic Survey, U. S. Department of Commerce, as a cooperating agency directly responsible for this phase of its mapping program. The Aero Service Corporation, Philadelphia, Pennsylvania, was engaged to furnish (1) two sets of aerial photographs of the country at 1:400,000 scale, (2) two sets of photo indexes of the photography and, (3) two sets of controlled photo mosaics at 1:20,000 scale.

For ground-control, 20 second-order astronomic positions using the zenith camera, were established for the Liberian Cartographic Service by Lt. John O Boyer, C&GS, and one aide. At four of these sites the Aero Service Corporation set up shoran stations for control of the aerial photographs taken during the period from December 1952 to March 1953. Adjustment of the shoran-net for control of the aerial photography was made by the Geodesy Division, Coast and Geodetic Survey. The geographic datum was determined by an averaging process involving the shoran-net and the four astronomic stations connected to it.

The mapping and training program for the Liberian Cartographic Service was designed to prepare its employees for compiling planimetric maps at 1:20,000 scale from the shoran-controlled mosaics of the same scale. The geographic coordinates of Hotine's Skew Orthomorphic projection plane coordinates were ruled for these controlled mosaics from tables prepared by the Geodesy Division and published by the Coast and Geodetic Survey.

It became apparent toward the end of 1953 that it might be some time before the 522 projected planimetric maps at 1:20,000 scale would be completed. To provide the Liberian Government with complete map coverage in less time from the materials then available at little additional cost, the Coast and Geodetic Survey proposed to compile and publish (1) ten maps at 1:125,000 scale, (2) two maps at 1:500,000