*Photogrammetric and Field Scribing**

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ABSTRACT: *The Atlantic Region of USGS, first to convert from drafting to scribing, will extend the benefits, especially cost reduction, by introduction of scribing into photogrammetric and plane table compilation practices.*

Although scribing a stereo-compilation was begun on coordinatograph type plotters, instruments with pantographs were also found adaptable by pencil drawing directly on the painted plastic sheet to develop a scribing guide.

Field completion of topo maps by scribing offers the topographer numerous advantages. The procedure results in an increase in quality, production, and economy of topographic mapping. Other tasks made easier by scribing include photogrammetric and field revision of old maps and field contouring of planimetric bases and controlled mosaics.

THE cartographic operation of color separation by scribing a coated plastic sheet is an established practice in the field of topographic map production. As one of the primary topographic mapping agencies in the United States, the Geological Survey has fully exploited this technique to achieve material savings in its map reproduction activities. The Atlantic Region, one of four operations offices of the Geological Survey, and the first to convert fully from drafting to scribing, has thereby reduced by about one third the number of man-hours required for the color-separation phase. Coupled with this arresting reduction in costs is the fact that the immediate product of scribing is a set of color separation negatives suitable for the printing of the press plates for the offset reproduction of the map. That this innovation revolutionized cartographic practices is a matter of record.

It is not proposed to include in this discussion a description of the methods and tools used in cartographic color separation. These have been given definitive treatment from the platform and in the literature. The object of this paper is to outline a second revolutionary change in the method of topographic map production brought about by the introduction of scribing techniques into photogrammetric compilation and plane table surveying. One is tempted to discuss terminology and job titles, subjects which engender debate whenever scribing personnel are considered. Your speaker yields slightly to the temptation by calling attention to the persistent practice of calling all who take stylus in hand, negative engravers. This "tail-wagging-the-dog" approach has little to commend it unless it be the slight resemblance between the implements used and those employed by glass negative engravers of the old school.

Those who use scribing techniques in photogrammetric compilation and plane table surveying have simply taken the conventional pen and ink or pencil drawing which creates the manuscript by adding substance to the drawing surface, and substituted for it the inverse operation of removing substance from the scribing surface. This form of subtraction is unique for it has resulted in the addition of many useful tools to the kits of the photogrammetrist and the field surveyor. Full exploitation of photographic and photomechanical processes is now possible and eliminates many of the tedious and error-producing hand operations traditionally associated with map production. Old timers in the topographic mapping business have been amazed by the immediate and cordial reception given scribing methods. A regional engineer of the Geological Survey was heard to remark that for the first time in his forty years of experience

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he was witnessing the introduction of a new plane table technique without a single objection from field personnel. Within a period of two years scribing methods have become standard practice in the Sections of Photogrammetry and Field Surveys of the Atlantic Region of the Geological Survey.

The reason for this rapid transition from old practices to the new was the discovery that the coated plastic is a superior drawing surface as well as a medium suited to the rapid scribing of fine map detail. Logically, therefore, the photogrammetrist should compile directly upon the paint thereby developing guide copy for the scriber without the need for intervening photographic operations. The copy can be scribed in streamlined fashion to produce a compiled manuscript which may be used to print both plane table sheets and extremely legible color separation scribing guides; or, for maximum economy, certain colors can be separated in the photogrammetric compilation phase, and by careful or final scribing, these component manuscripts can be converted into color separations from which press plates may be processed. Complete color separation concomitant with stereo-compilation is the ideal goal set for the scribing process. Experience may prove that the ideal is impracticable. For example, the black or cultural content of a topographic map compilation will often be subject to numerous changes as a result of field-completion surveys and editing; hence it does not seem likely that it will be economical to scribe the culture during the compilation phase in such a way that it can later be substituted for the conventional color-separation.

The following brief description of materials used in photogrammetric and field scribing is essential to a fuller understanding of procedure. Materials fall generally into three categories: (1) the plastic sheeting, (2) the coating, (3) auxiliary materials used for photographic and photo-mechanical processes. The plastic used presently throughout the Topographic Division of the Geological Survey is the polyester sheeting marketed under the trade name "Mylar." It is used in thicknesses of .003, .005, and .0075 inches. Cost per unit area is proportional to thickness because it is purchased by the pound in 36-inch rolls. At the current price the .005 Type D Mylar costs approximately $12\frac{1}{2}$ cents per square foot. The physical characteristics of Mylar are well known. It is the strongest plastic sheeting and its dimensional stability is adequate for mapping. The thermal and humidity linear expansion coefficients of coated sheets having the three gauges mentioned appear to be independent of thickness. Therefore one may vary the thickness of component manuscripts without creating register problems.

The coating most commonly applied to Mylar is a yellow, eggshell finish, quick-drying paint marketed under the trade name "Flopaque Scribecote." Coated Mylar may be purchased from various drafting supply houses. The Atlantic Region of the Geological Survey prefers to coat its own sheets by whirling, thereby controlling hardness, thickness, opacity, and scribability. Although whirling consumes paint at the rate of one gallon per 250 square feet, the cost of a sheet is less than that of the commercially available product. The paint now used is not the last word in coating. Research will inevitably discover new coatings colored with dye instead of pigment, yet possessing the necessary actinic characteristics as well as transparency and receptivity to sensitizing solutions and to drawing media. Presensitized coatings having a long shelf life would be most useful for military mapping units.

Much of the impact of scribing techniques on photogrammetric and field surveying practices may be attributed to the photographic processes available to prac-

titioners. Consider the simple operation of transferring edges between contiguous maps. What was once an arduous task requiring hours of error-producing handwork is now performed between scribed manuscripts in minutes by a photographic process. The materials used in the application of photography fall into two categories: (1) sensitizing solutions for direct printing from one scribed manuscript or negative to another coated sheet, or for photostencil printing or etching from a film positive to a coated sheet, and (2) ordinary photographic films and papers. The first class of materials is used to sensitize the coated sheets by hand with a cotton swab using any one of many bichromated substances. One commonly used solution is marketed in a variety of colors under the name "Watercote." If one wishes to impress photographically a stencil upon the painted plastic, he whirler-coats the sheet with one of the photo-resists used by lithographers to prepare deep etch plates. The exposed and developed stencil image may be either dyed or transformed into scribed form by wiping away or etching the paint with a suitable solvent to which the resist is inert. This elegant process, developed in the Atlantic Region, has been used to date to eliminate the hand scribing of certain map detail by cartographic personnel. There is no reason why it cannot be used in photogrammetric compilation to transfer edges in scribed form, thereby eliminating all handwork after the initial scribing. This subject must be dismissed with the comment that the possibilities of etching have yet to be fully explored.

The need to make composite prints from scribed component manuscripts for checking and advance publication purposes requires the selection of proper photographic materials. The yellow coating is quite suitable for prints on paper and blue sensitive film. Careful exposure will even permit the use of orthochromatic film due to the opacity of the pigment. More important to the photogrammetrist is the availability of a group of photographic materials marketed under the trade name "Kodagraph," which can be handled under ordinary room light and exposed in a vacuum frame to arc or sunlight. Also, prolonged exposure to fluorescent light will produce satisfactory prints. Specifically, the materials which need no darkroom for processing are (1) Repro-negative Extra Thin paper for making positive copies from scribed manuscripts or negatives; (2) Autopositive paper either extra thin or translucent for making either negative or positive copies from scribed manuscripts; and (3) Autopositive film for making either negative or positive film copies from scribed manuscripts. The latter two reversal materials have had their D log E curves pushed over the hump. A known but seldom exploited property allows them to be reversed by a preliminary exposure to arc light through a yellow filter resulting in a change of sign, so to speak, and making them equivalent to the Repro-negative paper. The D log E curve passes through a full cycle before the material is exposed to a printing medium. This property of Autopositive material makes possible the printing of a composite from a group of color separations consisting of both positives and negatives. One simply stacks up the positives in register over the film and reverses it by exposure through the stack to light from a single carbon arc filtered through yellow sheeting. The reversed film is then given a short exposure to white light through each of the negatives in succession to produce the desired composite. Other tricks may be performed but their description is beyond the scope of this discussion. The subject of photographic materials may be closed by a plea to the industry to market a low speed film equivalent to Repro-negative paper so that one need not reverse Autopositive film when required to make film positives from scribed manuscripts in ordinary room light. Furthermore, all of the emulsions would be more useful if they were available on a base having the physical characteristics of Mylar. This may not be a vain hope because a polyester base lithographic film called "Cronar" is soon to be marketed. If the producers of Cronar see fit to coat this base with an autopositive emulsion, then, to quote the promoter, "We'll be in business."

Although new scribing tools continue to make their appearance, the basic implement for photogrammetric and plane table scribers continues to be a phonograph needle clamped in a pin vise. For want of a needle the battle need not be lost, for one may substitute grandmother's hatpin. The field of scribing tools is a happy hunting ground for the improviser and the gadgeteer. Both seek to increase the speed and comfort of scribing and to

reduce the skill required to produce work of acceptable quality. A most useful special device is the rigid graver which constrains the stylus to ride perpendicular to the surface and permits the uniform scribing of heavy lines. Another universally used tool is the swivel type double, triple, and quadruple line road graver. Augmenting these basic tools are guide templets for special symbols and tool sharpening jigs.

These, briefly, are the materials and tools employed by the photogrammetrist and field surveyor to produce a topographic map by scribing. The remainder of this paper will be devoted to a short description of the sequence of operations. The first step consists of plotting and scribing the quadrangle projection and geodetic control data on the coated Mylar sheet. Edges to be joined are printed in register to this base sheet either from negatives of published maps or directly from the scribed manuscript of adjacent quadrangles. This photographic operation is a five minute process begun by swabbing the edge strip with a coating of the bichromated solution, followed by fan drying, exposure in a vacuum frame to the carbon arc light passing through the registered printing medium development of the image by sponging with a dilute solution of ammonia and concluded by towel drying.

Passpoint positions resulting from aerotriangulation are transferred to the base sheet in the adjustment process. Because the scribing procedure was introduced on the Zeiss Stereoplanigraph and Wild Autographs, compilation at the publication scale of 1:24,000 for $7\frac{1}{2}$-minute quadrangles presented no problem at the coordinatograph. Immediate success on these plotters made mandatory the modification of all other stereo-plotters, including the Multiplex, Kelsh plotter, ER-55, and Twinplex, by the attachment of a pantograph, enabling them to apply scribing methods to a reduced compilation scale. The pantograph further permits the use of stereotemplets for the adjustment of aerotriangulation. Using this attachment, the two-model templets can be plotted at compilation scale and assembled over either a single base sheet or a block of quadrangles, if necessary, to accomplish the adjustment.

The base sheets carrying the pricked passpoints are assigned to the stereo operators who compile the planimetric detail in pencil from models which are "roughed in" with sufficient accuracy to fit the passpoints. Correct absolute orientation is not necessary until later contouring. The completed planimetric compilation is passed to the scribing unit where the pencil copy is scribed with proper symbols and all vertical control data are labelled with elevations and identification.

The scribed planimetric compilation is used to print the planimetry on the sheet which will receive the topographic compilation. Exact register between planimetry and topography is assured by hand-punching register holes simultaneously through both the planimetric base and the underlaid contour base. A minimum of four holes, one near each projection corner, coupled with snugly fitting studs, serves to control register through all the subsequent printing operations performed in the photogrammetric, plane table, and cartographic phases. Usually a red image of the scribed planimetry is impressed on the contour base by the same process used for edge transfer. The image is made to read direct by printing through the .005 inch plastic. The plotter operator draws the contours in pencil from absolutely oriented models registered to the planimetry and levelled on the vertical control points. Legible copy is expected from the operator. If the contours lack character because of woodland cover or inferior model definition, he must re-pencil them to improve topographic expression. Complete re-penciling is unnecessary if the scribing of the contours is entrusted to the skilled hand of a topographer. Such an engineer-craftsman can not only smooth out by generalization those minor particularities characteristic of stereo-drawn contours, but also produce scribed topography of reproduction quality. This is a significant achievement for it permits color separation of the brown concomitant with photogrammetric compilation. The resultant savings in cartographic costs are appreciable in the case of dense topography which costs as much to scribe as all other colors combined. A coated .003 inch Mylar sheet is used for the compilation of the final brown separation to permit printing through the base when making the press plate.

In a strict sense the stereo-compilation of contours by scribing means the substitution of a stylus for the pencil in the plot-

ting instrument. The direct scribing of contours at the plotter offers the solution to a number of stereo-compilation production problems. Not all operators are physiologically nor psychologically equipped to record a contour with the frightening finality exhibited by a scribed line. But a "free wheeler" with a high acuity can produce, immediately, a printing medium of the contours for which there are a variety of uses. Provisional military maps could be produced by proceeding directly from the stereoplotter manuscript to the press plate. Peacetime map makers are provided with a solution to the problem created by flight strips which straddle quadrangle edges. The contours are scribed directly on a straddle strip from a single setup of the models. The apportionment of the entire strip is accomplished at once by selectively printing the strip in register to each of the adjacent quadrangles. The auxiliary strip is discarded and the compilation of contours continues in pencil from those models which fall wholly within a quadrangle. One realizes immediately the utility of this routine for handling the most economical photo coverage planned without regard to quadrangle boundaries.

Another application of direct scribing is multiple assignment of the compilation of a single quadrangle. The scribed planimetric base is fully printed to the master contour sheet. Auxiliary sheets are printed from parts of the planimetric base and one is assigned to each of the operators. Contours on the master sheet are drawn in pencil while those on the auxiliary sheets are scribed directly. The full quadrangle manuscript is a composite on the master sheet of the penciled contours plus a print from each of the component auxiliaries. This composite has proved to be excellent copy for final scribing by the topographer. In fact, that part printed from the auxiliary sheets is more legible than that compiled in pencil.

This result suggests the use of stylus to the exclusion of the pencil in the compilation of contours. The pencil requires constant sharpening whereas the stylus draws a uniformly fine line. The directly scribed contour compilation covering a full quadrangle can be treated as an intermediate product used solely in combination with the planimetric base to print a two-color composite on a third sheet which is scribed in final form by the topographer.

To assure proper registration between topography and hydrography, the planimetric compilation is sensitized and overprinted with an image of the scribed contours. By opaquing and rescribing where necessary the drain lines are made to agree with the contour reentrants. The completed photogrammetric manuscripts are checked both for content and registration on a composite print made on either Repro-negative paper or Autopositive film. After correction the component manuscripts are ready for the preparation of the field completion plane table scribing sheets.

Two-color plane table sheets are prepared on coated plastic in either quarter or half quadrangle size. Exact register is maintained by the use of at least two punch holes in each plane table sheet. The introduction of multi-color prints which may be scribed by the field engineer has revolutionized completion surveying practices. Field completion of a photogrammetric compilation involves deletions, corrections, and additions to planimetry and topography. The field engineer also classifies roads, buildings, drains, and occassionally woodland. He assembles editorial information including names, civil boundaries, and general instructions to office cartographers. Finally he checks the map for fulfillment of accuracy standards. Briefly, the field engineer scribes all data which will be subject to photographic processing in subsequent cartographic operations and he inks all other data on the face of the field sheet. The impact of this procedure on field completion practices gains emphasis from the following list of advantages:

1. Legibility of a multi-colored plane table sheet.
2. Improved drawing surface for pencil plotting and ink lettering.
3. Uniformly high quality of scribed corrections.
4. Proof of plane table sheet against soil.
5. Elimination of oversheets.
6. Use of low speed photographic materials for edge transfer in field quarters.
7. Overprinting of the field corrections on the compilation manuscript or on the color separation scribing guides.

Advantage (7) pertains to the processing of the annotated and scribed field com-

pletion sheets when returned to the office for further cartographic work. For example, the black color separation scribing guide is a reversed positive print of the planimetric compilation overprinted with the scribed field completion data. Corrections are made as the final scribing proceeds. In this way material savings are effected by avoiding needless corrections to the compilation manuscripts.

A form of field completion now undergoing test is executed on a print of the planimetric compilation but in advance of the contour compilation. Such advance field completion shows promise of being the most efficient application of scribing to field surveying. The field engineer's tasks include completion of the planimetry, determination of supplemental control elevations, contouring of flat areas and features difficult to interpret, and the establishment of test elevations. The test data are recorded on a separate sheet and are withheld from the photogrammetrist. All other scribed advance field completion data are printed in combination with the planimetry to form the contour base. After contouring, the test point elevations are interpolated and compared with their ground values. If the contours pass the accuracy test they are scribed in final form.

This outline of the scribing procedure as applied to the task of topographic map construction by photogrammetry and field surveying should suggest numerous other applications. The photogrammetric and field revision of old maps, the field contouring of planimetric bases and controlled photo-mosaics are but a few of the mapping tasks made easier by scribing. Doubtless the reader has already envisoned use of the technique to implement the topographic mapping operations of his organization. The introduction of scribing methods will inevitably follow the pattern experienced by the Topographic Division of the U. S. Geological Survey; traditionalists bow to success and before long there is not one Pharisee to be found among the scribes.

Type T231 Automatic Electronic Photo Printer

Because of military security, PSC Applied Research Limited has been unable until recently to reveal its part in pioneering the development of electronically-controlled auto-dodging. This printer represents a most significant improvement in the technique of photographic printing by using electronic control in "dodging" the negative during printing. The process provides a print on film, paper or glass which yields the maximum amount of information. Blocked shadows and chalky highlights are absent, and a useful photo print can be made from negatives hitherto regarded as unprintable. The improvement obtained with good negatives is equally impressive.

PSC developed the basic system of printing with a brilliant spot of light, projected from a cathode ray tube, which scans the negative and photo printing material. Variations of density in the negatives are sensed, and evaluated in special electronic circuits which compare the light value provided with that actually required to give the best possible print for the photo printing material in use. This information is fed back instantaneously to control the intensity of the printing beam; and in so doing automatically and correctly exposes each small area of the negative. Important factors are the scanning pattern and the size of the spot of light (as well as its spectral output), if the maximum dodging effect is to be obtained.

Equally important is the design of the electronic circuit which decides what brilliance adjustment is required for the printing beam as it scans each part of the negative. Prints may be processed at high speed while still in roll form. The necessity for "remakes" is eliminated.