# *Investigation of an Integrated Mapping System**†

LEON J. KOSOFSKY,
*Technical Development Staff,*
*Army Map Service,*
*Washington, D. C.*

ABSTRACT: *This paper reports progress on a continuing investigation of an integrated mapping system conceived around the profile scanning of the stereo model. Experiments and critical examination have narrowed down the selection of some elements of the system. Other experiments which are planned or in progress are described.*"

LEON J. KOSOFSKY

## INTRODUCTION

THIS is a report on the progress of the investigation being conducted at the Army Map Service on a mapping system based on the profile scanning of the stereo model. A previous report, appearing in the December 1957 PHOTOGRAMMETRIC ENGINEERING, under the inviting title, "Let's Go Over the Hill," presented the preliminary outlines of the system, and discussed its potential benefits and disadvantages.[1] In the year that has passed since that report was written, a few small experiments have been completed, several other are in process and much thought has been expended.

It will be recalled, from the earlier article, that the purpose of the system is to extract all the information needed for map compilation by examining the stereoscopic model just once, in a systematic manner. The three products which must come from this operation are:

1. *Plotted Contour Information.* This must come in a form suitable for the compilation of hypsometry to the required standards.
2. *Orthographically Positioned Photographic Detail.* Since this is to be the source for the compilation of all planimetry, the imagery must be sharp enough for easy recognition, and must meet the required standards for horizontal accuracy.
3. *Stored Profile Data.* This must be

[1] Spooner, C. S., Dossi, S. W., and Misulia, M. G., PHOTOGRAMMETRIC ENGINEERING, Vol. XXIII, No. 5, December 1957, pp. 909–920.

* Presented at the Society's 24th Annual Meeting, Hotel Shoreham, Washington, D. C., March 27, 1958.

† The information contained herein does not necessarily represent the official views of the Corps of Engineers or the Department of the Army. On 17 March, the Office of Security Review (OASD L&PA), Dept. of Defense, stated "No objections to publication on grounds of military security."

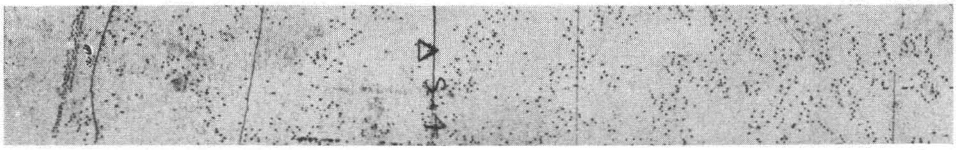

FIG. 1. Dropped Dots. 50 Profiles. Map scale 1:25,000. Contour interval 20 feet.

suitable for guiding the later carving of master terrain models.

The current and planned investigations will be discussed as they affect these three goals.

## SECTION I. PLOTTED CONTOUR INFORMATION

### 1. EARLIER THOUGHTS

The first report outlined three possible ways of plotting the contour information extracted by profile scanning. One method is to carve a laminated wax block directly, by routing profiles in the block simultaneously with the scanning of the stereo model. If the layers of wax are of alternating colors and the carved block is photographed orthographically, a plot of contour bands is produced. While this method has been shown to be feasible, it has serious disadvantages as a practical means of map production in quantity. Among these are inaccuracies due to the variable thickness of the wax layers and the makeshift construction of the Bench Camera at the Army Map Service, and the fact that it requires the production of a terrain relief model for each stereo model mapped.

The other two methods use a coordinatograph which is driven by the scanning of the stereo model. In the "dropped dot" method, the coordinatograph stylus marks a dot each time a profile crosses an elevation which is a multiple of the contour interval. In the "dropped line" method, the crossing of any such elevation causes the stylus to be raised from or lowered to the drawing position. Thus, if a 10-foot contour interval is selected, a profile rising from sea level will be represented as a solid line between 0 and 10 feet, blank between 10 and 20 feet, solid between 20 and 30 feet, etc.

### 2. TESTS

Mr. Robert A. Penney, who at that time was employed in the Development Branch, Photogrammetric Division, Army Map Service, performed several experiments to explore the problems connected with the "dropped dot" and "dropped line" methods. A Zeiss C-8 Stereoplanigraph was used, because of its known accuracy (the result of a previous instrument evaluation test), and the convenience of its coordinatograph and its $z$ counter reading system. In all scanning tests, the stereo operator merely traversed the stereo model in the $y$ direction, while continuously keeping the floating mark in contact with the ground. A second person continually watched the $z$ counter and actuated the coordinatograph pencil each time one of the pre-selected contours was crossed.

By the time the first 50 profiles had been plotted by dropping dots, it was apparent that there would be great difficulty in compiling contours from a plot of dropped dots. Figure 1 is an illustration of the dot plot of 50 profiles.

Figure 2 shows the plot of dropped lines for the same profiles. Its advantage as a base for the compilation of contours is easily seen. As a result, the method of dropped dots has been eliminated from further consideration as a component of the integrated mapping system.

Two models were scanned in the line-dropping tests. One covered an area in the vicinity of Phoenix, Arizona, using photographs which had been previously used in instrument evaluation tests. The second, covering a portion of the Yakima, Wash-

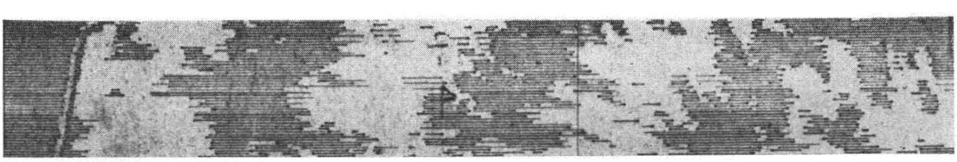

FIG. 2. Dropped Lines. 50 Profiles. Map scale 1:25,000. Contour interval 20 feet.

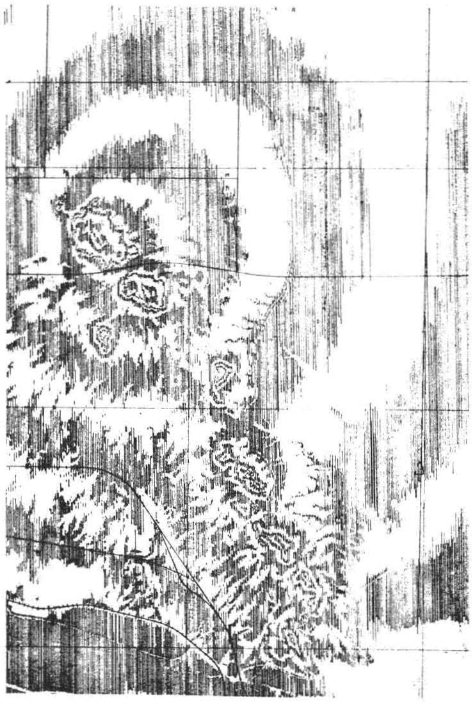

FIG. 3. Dropped Line plot, Phoenix Model. 50 Profiles/inch. Scale before reduction 1:25,000. Contour interval 20 feet.

ington Firing Range, was chosen to provide experience with a different type of terrain.

The Phoenix photography had been exposed at 20,000 feet. The model was oriented at a scale of 1:20,000. The profile scans were spaced at fifty profiles per inch. The contour interval was 20 feet. (Only 100-foot contours could be shown in the two highest areas.) Figure 3 is a reduced copy of the dropped-line plot. Figure 4 shows the contours compiled from Figure 3. The compilation was performed without the aid of any material other than the dropped-line plot.

The Phoenix area is not a particularly favorable one for demonstrating the appearance of a typical dropped line plot. The terrain consists of block mountains rising abruptly from a flat desert floor. The Yakima area, on the other hand, is in a region of considerable relief in a mature stage of dissection. Thus there are no level areas and few cliffs. This accounts for the more pleasing appearance of Figure 5.

The photography here had been exposed at 30,000 feet. The model was oriented at a scale of 1:30,000, and the spacing was again 50 profiles per inch. The contour interval was 100 feet, except for the last 50 profiles on the left side of Figure 5, which were run using a 20-foot contour interval. Figure 6 shows the contour compilation obtained from the dropped-line plot of Figure 5.

### 3. EFFECT OF PROFILE SPACING

The tests were performed at a spacing of 50 profiles per inch, because that appeared to be the closest spacing which could be used in a practical mapping system. As Figure 6 shows, it was quite feasible to draw the 20-foot contours, as well as the 100-foot contours. The only difficulty encountered was at the ends of the narrow strip of 20-foot-interval profiles (the areas marked 1 and 2 on Figure 6). It is safe to say that if the entire model had been profiled at a contour interval of 20 feet and a spacing of 50 profiles per inch, contours could have been drawn readily from the plot. Since a 20-foot contour interval for the Yakima photography represents an effective *C*-factor of 1,500, it can be assumed that the errors brought about in the drawing of the contours would be

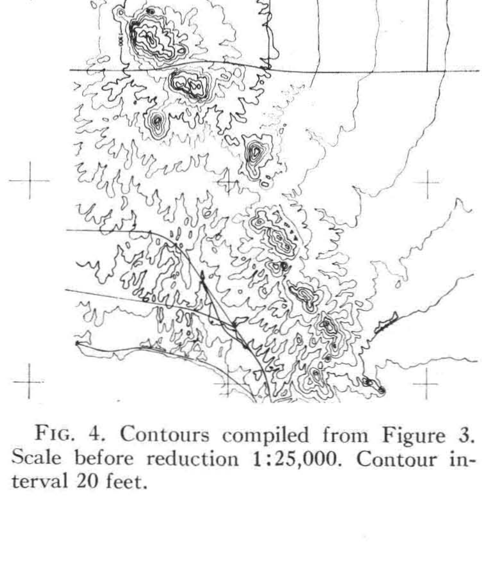

FIG. 4. Contours compiled from Figure 3. Scale before reduction 1:25,000. Contour interval 20 feet.

small compared to the instrumental errors.

The effect of coarser spacing was superficially investigated by redrawing the dropped line plot with alternate profiles eliminated. Figure 7 was prepared from Figure 5 in that manner, simulating a spacing of 25 profiles per inch. When contours were compiled from the new plot, it was found that no significant detail was lost where the contour interval was 100 feet. It was impossible to draw contours for the portion of the model which was profiled at a 20-foot contour interval. A much more thorough investigation will be required to establish the optimum spacing for various conditions.

It should be noted that if the tests had been made with a Kelsh Plotter, the spacings would have been increased to correspond to the instrument magnification.

The time required for compiling the contours from the dropped-line plot can be substantially reduced by color-coding the plot. We could replace the coordinatograph pencil with a small number of pens of different colors and a selector device for automatically switching pens. By using as few as three pens, we could remove all elevation ambiguity from the plot.

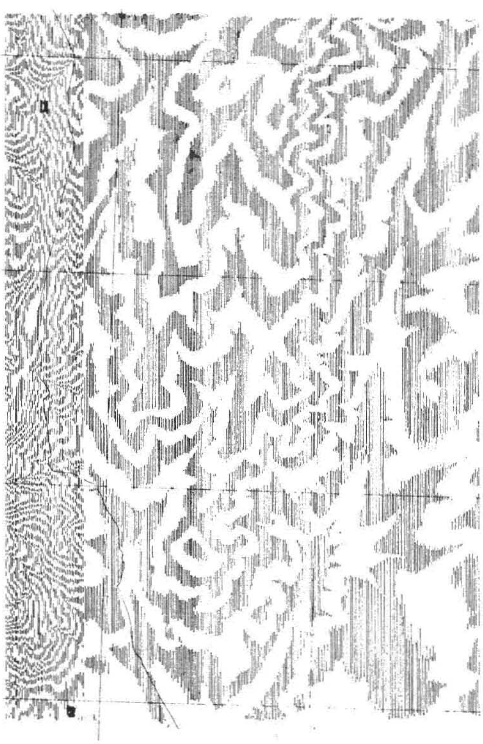

FIG. 5. 50 Profiles/inch. Scale before reduction 1:30,000. Contour intervals 20 feet–100 feet.

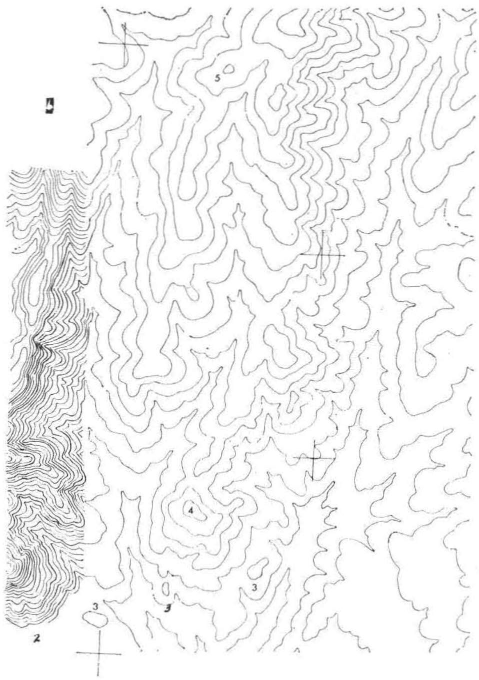

FIG. 6. Contours compiled from Figure 5. Scale before reduction 1:30,000. Contour intervals 20 feet–100 feet.

## 4. COMPARISON WITH CONVENTIONAL CONTOURING

a. *Completeness.* Figure 8 is a contour plot of the Yakima model which was compiled by conventional contouring methods. The instrumental setup was unchanged from the line dropping test. Comparison of Figure 8 with Figure 6 shows two areas, marked 4 and 5 on both figures, where hilltops were missed in the conventional contouring although they were clearly indicated in profiling. The three areas marked 3 show places where the shapes of isolated hilltop contours were altered considerably in the conventional contour plot. These differences are of course a consequence of the fact that profiling compels the stereo operator to examine all parts of the model in detail.

b. *Accuracy.* No precise determination of the accuracy of the Yakima model was possible, because of the inadequacy of the control. The Phoenix model, however, did permit a measure of direct comparison

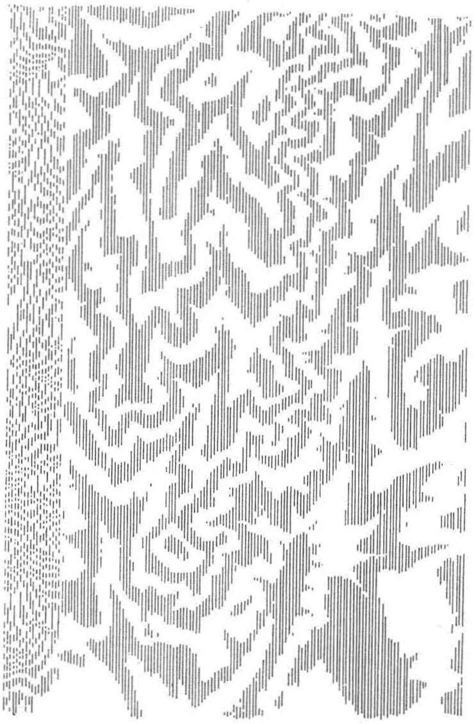

FIG. 7. 25 Profiles/inch. Scale before reduction 1:30,000. Contour intervals 20 feet–100 feet.

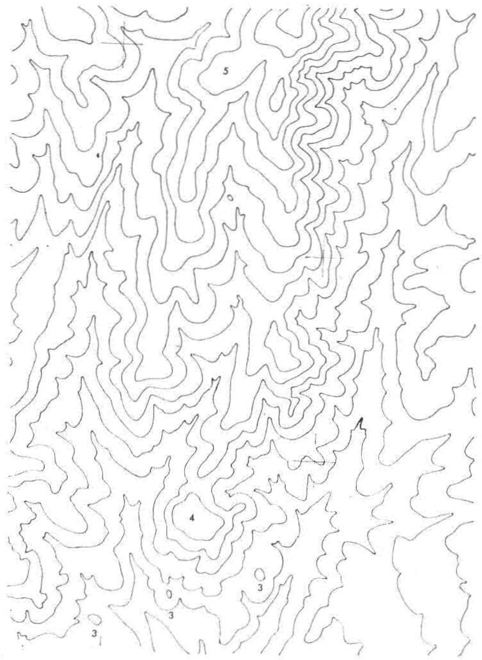

FIG. 8. Conventional Contours, Yakima Model. Map scale 1:30,000. Contour interval 100 feet.

with the usual contouring methods. The same instrument and diapositives had been used earlier in an instrument evaluation test. In the earlier test, the elevations of 84 field-established vertical control points had been compared with elevations obtained by interpolation from a conventional contour plot. For the present test, two contour compilations were made from the dropped line plot shown in Figure 3. One was made with no recourse to hydrographic or source map positioning detail. This is the compilation illustrated in Figure 4. The second compilation was made with the aid of a drainage overlay and source material. The interpolated elevations of the 84 control points were compared with the field elevations, as in the case of the conventional contour work.

The root mean square error of the test contours was calculated from the formula:

$$RMSE_{tc} = \pm \sqrt{\frac{\Sigma(X - M_x)^2}{N}},$$

where:

$X$ = difference between contour and field value.

$M_x$ = arithmetic mean of the measured differences.

$N$ = number of points read.

The results were expressed in terms of indicated $C$-factor by the formula:

$$C = \frac{H}{3.3\ (RMSE_{tc})},$$

where:

$H$ = photographic flying height.

The results are shown in Table I.

TABLE I. ACCURACY OF TEST CONTOURS

| *Test Compilation* | *Indicated C-Factor* |
|---|---|
| 1. Unaided contour forming from dropped-line plot | 1,250 |
| 2. Contour forming from dropped-line plot, aided by reference to source material | 1,429 |
| 3. Conventional contours from instrument evaluation test | 1,667 |

In assessing these results, it should be pointed out that the field control points were concentrated almost exclusively in the flat portions of the terrain. In future tests, it is planned to close an area which is more evenly and densely covered with field-determined vertical check points.

Future tests will also seek to eliminate a few additional variables which might affect the validity of the accuracy determinations. One factor which probably operated to the detriment of the line dropping accuracy was the lag occasioned by the use of a second person to actuate the coordinatograph pencil. This will be eliminated by construction of an automatic device. Another factor whose effect is unknown was the use of the Stereoplanigraph, which is not normally used at the Army Map Service for stereoplotting operations. Future tests will be conducted on a Nistri Stereoplotter, which combines coordinatograph operation with a familiar type of anaglyphic projection plotter.

c. *Speed Comparison.* It is possible to make a direct comparison of compilation times for the Yakima model. Thirty-four hours of instrument time were required to complete the 250 profiles at the 100-foot contour interval. An additional 45 minutes were required to form the contours. The same area was compiled (at 100-foot contour interval) in the conventional manner in 4 hours, with 30 additional minutes required to shape the contours.

An interesting characteristic of profile scanning is that the time required to cover a model is independent of the contour interval. It would have taken the same 34 hours to profile the model at a 20-foot contour interval. With conventional contouring, on the other hand, reducing the contour interval from 100 feet to 20 feet would have meant approximately a five-fold increase in time.

Alternatively, if only 100-foot contours were to be drawn, the profile spacing could have been increased to 25, or perhaps 20, profiles/inch.

Even after allowance is made for this, and for the complete lack of experience in profile scanning, it is doubtful that profile scanning can be accomplished more rapidly than present contouring methods, unless some instrumental assistance is provided for the stereo operator. The nature of the assistance which could be supplied will be examined in the next section.

## 5. THE ACT OF PROFILING

a. *Nistri Veltropolo.* The Nistri Stereoplotter which will be used in further profiling experiments is equipped with the Veltropolo. This is a device combining a variable speed motor drive with a direction resolver. It takes the place of the $x$ and $y$ handwheels of other stereoplotting and triangulation instruments. In conventional contouring with the Veltropolo, the operator steers the floating mark with the direction resolver, which looks like a steering wheel. The straight-up position of the steering wheel moves the mark in the $+y$ direction, the straight right (or 3 o'clock) position moves the mark in the $+x$ direction, and an intermediate position moves the mark diagonally. The operator controls the speed of the drive with a hand lever. His foot controls permit both motor drive and foot drive of the $z$ motion.

The Veltropolo can be used in two ways for profile scanning. In one method, if the scans are to be made in the $x$ direction, the steering wheel is set to produce only $x$ motion. The operator uses the hand lever to control the speed of the $x$ drive, and the foot controls to keep the floating mark on the ground.

The second method is more novel. It is possible, by switching electrical connections, to use the direction resolver in the $x-z$ instead of the $x-y$ plane. Then the operator can use his steering wheel to parallel the slope of the ground in the direction of scan. While this appears to be a promising method, it will have to be tried before we can know how much it will speed the act of scanning. Scanning tests using both methods are planned for the near future.

Incidentally, in all tests with the Nistri Stereoplotter, the preferred direction of scan is the $x$ direction. The first scan is at the front of the table, with successive scans moving toward the center. When the center is reached, the operator moves to the back of the table (the Veltropolo control is on casters) and successive scans are closer to him.

b. *Memory-Aided Profiling.* While it is likely that the use of the Veltropolo will shorten the time required to run a profile, the improvement is not expected to be drastic. Even with motor-driven motions, the operator must still cause the floating mark to make large motions in the $z$ direction while he maintains the delicate control necessary to conform to small changes in elevation.

The most promising solution to this problem was first suggested by Mr. Bernard S. Benson, President of the Benson-Lehner Corporation, Los Angeles, California, during a visit to the Army Map Service. He pointed out that when profiles are closely spaced, the terrain does not change much between profiles. Put another way, the simplest way to predict the shape of a given profile is to trace out the adjacent profile. If a profile can be stored while it is being scanned, and then played back while the next profile is being scanned, the floating mark will have stayed close to the ground during the second scan. The operator will no longer have to make the major excursions in $z$ himself. He can be provided with very fine controls, which he will use to over-ride the played-back profile so that it conforms to the profile being scanned.

This is the kind of idea which makes one ask, "Why didn't I think of that myself?" It offers the real prospect of making the profile scanning operation faster than conventional contouring. For that reason, all of our thinking about instrumenting the system as a whole has been based on the provision of memory-aided profiling.

At first thought, it would appear that the storage and playback equipment does not have to be very precise, since the playback is performed only for the purpose of being over-ridden by the operator. Unfortunately, further reflection shows that, to be really useful, the precision must be comparable to the smallest elevation differences perceptible to the operator. We want to arrange matters so that the operator has only to correct for the genuine differences between successive profiles. If we also force him to correct for apparent differences due to the lack of precision of the equipment, we are limiting our assistance to him.

In some ways, the task of the operator in memory-aided profiling is analogous to that of a truck driver on a winding road. After the driver has turned his wheel to approximate the curvature of the road, he continually observes the position of his truck on the lane, and makes the necessary minor corrections to the wheel position. But if his truck has a loose steering linkage, he would have to "fight the wheel" in order to stay in position. Similarly, the stereo operator with an inaccurate memory system would have to struggle with his controls.

## Section II. Orthographically-Positioned Photographic Detail

### 1. Requirements Imposed by Integrated System

Orthographically-restituted aerial photography is in use today for various applications. The U. S. Geological Survey produces orthophotographs principally as a base for the plotting of geologic field observations. At least one private mapping company (R. M. Towill Corporation) produces orthophotographs which need only the addition of contour lines to serve as the final map product. Orthophotographs as conceived in the integrated mapping system are used for a third purpose, i.e., as the source from which all planimetric detail is compiled. This conditions the requirements imposed on their quality and on the manner of their production.

a. *Positional Accuracy.* If orthophotographs are to serve as a map compilation base, the positioning of all detail must of course meet national map accuracy standards. This does not appear to be a problem. In fact, if orthophotographs are to be printed during the act of profile scanning for the dropped-line contouring plot, we cannot meet the vertical map accuracy standards without producing acceptably positioned photography.

b. *Image Definition.* We don't know how sharp an orthophotograph has to be to form a usable compilation base. Certainly, high resolution and good definition must be important factors in determining the efficiency of the compilation work. Tests are now in progress which will give us some qualitative experience with these factors.

The Development Branch, Cartographic Division, Army Map Service, is attempting to compile planimetry under conditions which simulate those of the integrated mapping system. The compilation base is a set of orthophotographs which was produced by the U. S. Geological Survey. Since the area covered is part of a quadrangle recently published by the U. S. Geological Survey, all the color separation negatives are available. Only the brown (contour) separation is given to the compiler. This simulates the contour compilation which would have been prepared from the dropped-line plot after profile scanning. The compiler must compile the hydrographic and culture separations, which will be compared with the blue and black separations supplied by the Geological Survey. The compiler can consult contact prints of the aerial photos if he finds it necessary. We plan to repeat the test, using a set of poorer quality orthophotographs.

c. *Compatability with remainder of system.* As the system is now conceived, the production of orthophotographs must not require the stereo operator to scan his model a second time. Also, it should not hinder him in his task of producing the dropped-line plot. In addition, it would be nice if the equipment necessary to produce orthophotographs did not add much complexity or expense to the total instrumentation. These requirements are not easily met, as I will attempt to show in the next few minutes.

2. LIMITATIONS OF AVAILABLE INSTRUMENTS

a. *The U. S. Geological Survey's Orthophotoscope.* The Orthophotoscope now in use at the U. S. Geological Survey is a development model. It is not compatible with an integrated mapping system. It functions by profile scanning of the stereo model, but the operator cannot produce a good dropped-line plot for contouring while he is producing an orthophotograph. This is partly a consequence of the fixed width of scan, and partly because of the fixed speed of scanning.

The Orthophotoscope scans at a fixed speed in order to provide uniform exposure for all parts of the negative it produces. The operator who has this bear by the tail cannot really keep his floating mark right on the ground during the whole scanning operation. He does the best he can, which turns out to be good enough to meet any reasonable horizontal accuracy requirement. As I explained earlier, this is not nearly good enough to meet standard vertical accuracy requirements.

Another disadvantage of the Orthophotoscope is that it occupies all the available model space under the stereo projectors. It would be difficult to find room for any other equipment needed for the system.

b. *Photo-Electric Vibrator.* In the hope of eliminating the necessity for uniform speed, we investigated the possibility of adapting a photoelectric scanner which produces an image of halftone dots mechanically engraved in plastic. The conclusion was reached that images of the same quality as those produced by the Orthophotoscope could not be attained in this manner. For one thing, the photomultiplier tube, which is used to pick up the projected image, integrates all the light hitting its sensitive spot. Thus, the resolving power of the image pick-up is determined by the spacing of scans. A spacing of 50 profiles/inch, which is the finest spacing contemplated for dropped-line contouring, would produce an electrical image with a resolution of 1 line/millimeter! The dot-engraving method of converting the electrical image to a tangible image is also limited in its resolution capabilities, as compared to a photographic process.

3. POSSIBLE FUTURE DIRECTIONS

a. *Use of the Memory System.* There is at least one way out of the conflict between the constant speed requirement for exposing the orthophotograph and the necessity for variable speed in dropped-line contouring. We have already considered the memory system essential to a practical integrated mapping system. We can make it do double duty.

A profile which has been stored in the memory system can be played back at a constant (and rapid) speed for printing before it is played back at variable speed to aid in the forming of the next profile. In fact, it is not necessary to play back every profile to expose an orthophotograph In the interest of saving time, at some cost in horizontal accuracy, every other scan, or possibly every fourth scan, could be played back for printing.

b. *New Model USGS Orthophotoscope.* In the design of their future Orthophotoscope, the personnel of the U. S. Geological Survey have taken some steps to make the instrument more compatible with an integrated mapping system. I am sure that they would prefer to make their own report on the instrument at the proper time. It is sufficient to point out here that the new model Orthophotoscope will have servo-drives which could be controlled by any suitable playback system.

This is perhaps the best place to acknowledge the helpful spirit in which Mr. Russell K. Bean and his colleagues at USGS have cooperated with the Army Map Service by supplying orthophotographs and drawings and modifying their designs. A working group has been set up

by the two agencies to exchange information and plans. The USGS members are Messrs. J. G. Lewis, R. B. Southard and J. T. Pilonero.

c. *Photoelectric Image Pickup.* When orthophotographs are produced by direct exposure, under an instrument such as the Kelsh plotter, they must be produced at viewing scale. This scale is often inconveniently large. Also, the film must be positioned where the image is, regardless of any other requirements for the same space. Flexibility in both respects can be gained by catching the projected image on a suitable photoelectric tube. The image can be transmitted electrically to a cathode ray tube, which exposes a film on a remote coordinatograph. As explained in the case of the photoelectric vibrator, a phototube which integrates the light falling on its sensitive area cannot produce a suitable picture in the application. But a scanning phototube similar to those used in television, which scans the image formed on its sensitive surface, can provide much higher resolution. A half-inch tube is made which is small enough to go in the position of a Kelsh plotter tracing table. There will be some resolution loss as compared with directly exposed orthophotographs, but it should be a small loss in a properly designed system.

The increased flexibility of a system employing photoelectric pickup opens up several interesting possibilities. For example, we could have a two-story coordinatograph which would be used to make the dropped-line plot and the orthophotograph simultaneously. A second possibility is a central coordinatograph which would be connected to a number of stereoplotting booths and would produce orthophotographs for all of them.

## Section III. Permanent Storage of Profiles

### 1. USES

The primary use for permanently stored profiles is the later production of relief model master molds. Previous experiments conducted by the Relief Map and Photogrammetric Divisions, Army Map Service,[2] showed how relief models can be carved directly by profile-scanning the stereo model. It is desirable to have an intermediate storage step between the profile-scanning and model-carving steps. This permits flexibility in scheduling to meet demand for maps or models. It also permits a free choice of scales and vertical exaggerations for the relief models.

There are other possible uses for stored profiles. They can be fed into a computer which will determine the volumes of earth to be moved in a construction project. They can be used to solve problems of line-of-sight defilade, as for example in choosing a location for a television relay tower.

### 2. REQUIREMENTS IMPOSED BY RELIEF MODEL USE

In everything discussed so far, the integrated mapping system has been related to the single stereo model. Maps and relief models, however, are produced in a quadrangle format. This does not impose a problem in the production of maps. Dropped-line plots and orthophotographs extracted from individual stereo models can be pieced together into quadrangle format before compilation is attempted.

In the case of relief model production, the marriage of small individual models into one quadrangle-sized model is a very laborious process. It would be very desirable if the stored profiles from which the models were to be carved were initially in quadrangle format. There does not seem to be any way to this do without the addition of much complex equipment.

Mr. D. H. G. Van Bergen, of the Development Branch, Relief Map Division, studied this problem. His conclusion was that the production of relief models from stored profiles would be materially aided if all the profiles for a single flight line were parallel and colinear. The operational requirement this imposes is that guiding profile lines must be laid out before the individual stereo models are oriented in the stereoplotters. The equipment for storing profiles must also be capable of indexing them and retrieving them by number.

### 3. STORAGE MEDIUM

The most convenient way to enter the profiles into storage, from the operator's viewpoint, would be to have them transferred automatically from the temporary storage of the memory-aided profiling

[2] AMS Final Technical Report "Stereo-Carving Instrument Development," dated 30 November 1956.

equipment. At present, we believe that the permanently stored profiles will require less fine detail then the memory system. Actually, it is not yet clear just how much detail is desirable. We are planning to measure and record a large number of actual profiles from typical stereo models so that our computing equipment can determine the density of stored detail required to convey the essential information about an area.

Magnetic tape seems to be the most convenient storage medium. However, the possibility of using graphically scribed profiles will not be ruled out until we know more about the amount and precision of the required detail.

## Section IV. Future Plans

The investigation is being continued along two major lines. First, we will get all the information and experience we can with the equipment now on hand. We are learning about the speed and accuracy of profile scanning with the Nistri Stereoplotter. We are compiling map detail from orthophotographs. We will record actual profiles to learn how the information can be condensed for storage.

The second line of investigation is the construction of experimental equipment with which to test the main features of the system as it is now conceived.

The present plan is to prepare specifications for the design and fabrication of equipment to be used in conjunction with our Nistri Photomapper. The equipment is to provide the capability for memory-aided profiling, and for the production of orthophotographs with no additional stereo measurement. Consideration will be given to converting the profile information into a form suitable for permanent storage.

Any long range plans in this field should take into account the likelihood that automatic terrain-following equipment will eventually be developed for use in stereoplotting. The experiences of the Engineer Research and Development Laboratories, Wright Air Development Center, and Hycon Manufacturing Company in attempting to develop such equipment have brought to light some of the difficulties involved. Nevertheless, eventual success is to be expected. Where will the integrated mapping system stand then? Most probably, the automatic equipment will operate by profile scanning, because that is the most efficient way for a machine to search the model space automatically. This point is discussed thoroughly in an Engineer Research and Development Laboratories report prepared by Mr. E. R. DeMeter.[3] The equipment will probably make use of some form of memory-aided search in its profiling. The type of assistance suitable for a machine will doubtless differ from that which would be provided to a human operator.

If automatic profile-scanning equipment is successfully developed, an integrated mapping system basically similar to the one outlined here will have even greater advantages than at present. All mapping operations which require human judgment will then be performed away from the automatic stereoplotter.

Meanwhile, the potential benefits of the system are enough to justify its continued investigation on the scale planned.

[3] ERDL Report 1488-TR, 16 July 1957, "Automatic Contouring Instrumentation."