from other sources. Also it should be borne in mind that profiles, like contours, can be best drawn when there is no interference from vegetative cover; when forest cover prevails, an accurate profile would be difficult if not impossible to determine.

As the geologist becomes better acquainted with photogrammetric instruments, and they are made more available, profile plotting with instruments of this type will increase. The ease and reliability of photogrammetric profile plotting should lead to more use of profiles than has been heretofore possible.

*Medium-Scale Charting—A Challenge to Photogrammetry**

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ABSTRACT: *This paper explains some of the complexities encountered by the Aeronautical Chart and Information Center in compiling medium-scale charts by photogrammetric methods. Areas are charted in various parts of the world using a large variety of source material, many types of photography, and available but limited amounts of geodetic control. This requires the use of numerous procedures and techniques to accomplish chart production. Greater emphasis is planned on rapid photo revision techniques. Examples of materials available and methods of meeting the challenge are presented.*

MEDIUM-SCALE charting by definition is charting accomplished for publication at scales ranging from smaller than 1:100,000 and including 1:500,000. This definition is considered logical in view of a large number of aeronautical publications being printed at scales of 1:1,000,000; 1:2,000,000; 1:3,000,000 and 1:5,000,000. Examples presented in this paper were taken from charts prepared for publication at 1:250,000 scale.

The principal elements of medium-scale charting which constitute the challenge to photogrammetry are as follows:

1. As a multi-purpose chart produced by the Air Force the 1:250,000 scale chart is the leader. This Aeronautical Approach Chart is a basic chart for strategic and tactical air operations (including air-ground support, interdiction, target run navigation and bombing). It satisfies to a large extent the large-scale planning and intelligence requirements as well. Because of its many uses and the development of the new weapons systems which have been described in the newspapers, this chart must conform to the most practicable accurate standards. Accuracy is the first element of the challenge.

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2. Large areas in many parts of the world must be charted. The resulting

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charts must be maintained to reflect current cultural conditions. Every geographic condition, ranging from mountain to desert and from tundra to tropical swamps, can be encountered among the large number of Approach Charts already published. The problems, associated with the photo identification and classification of chart features in such diverse areas, will impress those who have had even a limited contact with such problems.

3. Photography flown specifically for mapping purposes is used when available; however, there are many areas of the world where it is necessary to use any available photography. Reconnaissance photography constitutes the largest part of that used in medium-scale charting. This normally consists of vertical photographs of a more or less uniform scale, or trimetrogon photography taken from heights ranging from 10,000 to 30,000 feet. Foreign photography which is available and capable of supplementing information contained on the standard photography may also be used. The Aeronautical Chart & Information Center must therefore be extremely flexible in adapting its procedures and techniques to many varieties of basic source material, photography, and control distribution.

4. The final element of this challenge and, as usual, one of the most important is the element of time and money. This element, in itself, makes each and every compilation a very real challenge to the Aeronautical Chart & Information Center. Air Force requirements necessitate a rigid budgetary control on both the time and money allowed to complete each assignment.

Thus, the challenge of medium-scale charting to Photogrammetry consists of compiling the most accurate charts possible in diverse geographic areas, using large varieties of source materials and photography, and completing these charts with a limited amount of time and money. A brief review of several recently completed assignments will illustrate some aspects of this challenge.

The first type of compilation for discussion is "*Photo Revision.*" This is the process of revising existing compilations or preparing new compilations from existing outdated source maps which are reliable insofar as relative position of detail is concerned. These maps or charts are made current by use of late-date photography. Figure 1 illustrates information extracted from two existing aeronautical charts, one published in 1953 and the other in 1955. The cross-hatched area represents the development of city areas subsequent to the date of the latest information incorporated into the original chart. In this particular area, a new city has appeared and older cities have more than doubled their original size. The major transportation routes have remained almost unchanged during the period of this development, and in this diagram, no attempt has been made to show minor changes. It should be noted that these changes are representative of those that have occurred throughout the chart area and do not constitute an extreme example.

This particular revision was accomplished by use of source maps, 1:25,000 scale, containing a rather dense network of roads and railroads. As an intermediate step, a selection of features was made on overlays to these source maps and photo revisions were accomplished by vertical projectors and sketching. The process was comparatively rapid, since association of photographs and maps was a relatively simple matter. Errors introduced into the manuscript were reduced to 10 per cent when these overlays were brought down to the final drafting scale of 1:250,000. Topography was adequate on the existing source and no revisions were required.

Alternate methods of accomplishing photo revision are as follows:

1. Revise directly the existing 1:250,000 scale manuscript. The relative scarcity of detail and the large scale of photography makes the process of associating photographs with the manuscript much more difficult as well as less accurate.

2. Revise reduced source maps paneled to a projection.

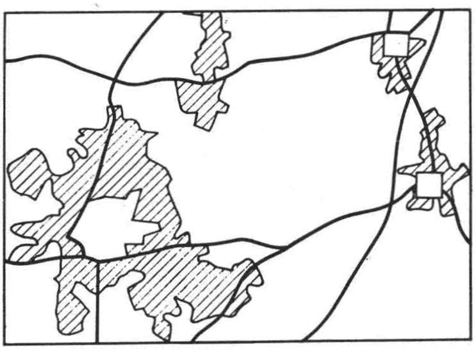

FIG. 1. City development, 1953–1955.

3. Enlarge or reduce source maps, or photography, to a scale of the correct proportion for the use of sketchmasters.
4. Use rectified prints scaled to the manuscript or source map.
5. Use stereoscopic plotters such as the Ryker-Mahan, Multiplex or some similar instrument. Multiplex projectors have been used singly as well as stereoscopically to accomplish photo revisions. Annotations were made on overlays of photographs and reduced to diapositive size for insertion into the projector.

The Aeronautical Chart & Information Center has tried all of the above methods and many others too numerous to describe. Experience has shown that under certain conditions, one method is more suitable than others. Good judgment is required to select the most appropriate. A requirement exists for an instrument which will allow the direct comparison of photography to chart manuscripts, in the range of compilation scales associated with medium-scale charting.

The increasing volume of photo revision assignments necessitated delegation to less experienced personnel of the simpler types of photo revisions which did not require photogrammetric equipment. A training program in the use of photographs permitted the Center to increase its potential through increasing the number of photo revision employees available and also by releasing the more highly specialized photogrammetric technicians from the burden of the less exacting compilations. It is expected that this trend toward a larger volume of photo revision assignments will continue.

The next type of charting is that which uses trimetrogon photography. The trimetrogon concept of charting resulted from the need to obtain photo and chart coverage of extremely large areas in a short time span. Until some other system is developed which will insure sidelap of flights with the same efficiency and economy, the trimetrogon system will be maintained as a ready tool of the Air Force. Figure 2 illustrates two trimetrogon flights and the relationship which assures sidelap.

In its theory, this type of charting encompasses a great deal of photogrammetry, but in practice it lends itself so well to production-line methods that it appears to be simplicity itself. Trimetrogon charting is not static, and improvements in instruments and techniques have occurred in almost every phase in recent years.

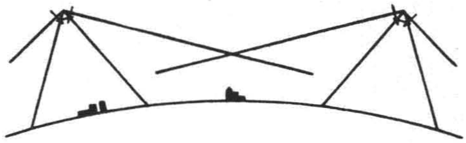

FIG. 2. Trimetrogon system of photography.

Stereoscopic compilation of many varieties are completed by the Aeronautical Chart & Information Center. Instruments used range in complexity from the Stereocomparagraph to universal plotting instruments such as the C-8 Stereoplanigraph or the Wild A-7 Autograph.

When standard photogrammetric mapping photography is available and control distribution is similar to that shown on Figure 3, the compilation procedure adopted usually involves the use of multiplex equipment if a small contour interval is required. Most mapping organizations have compiled maps under similar conditions using similar equipment.

Figure 4 shows a stereo templet assembly of one of the most recent compilations. The details of stereo templets have been previously described by Marvin Scher of the U. S. Geological Survey.[1] The Kelsh plotter was used in this particular assembly, and stereo operators found this new technique very proficient in charting areas of extremely limited control. There is a feeling among stereo operators of the Aeronautical Chart & Information Center that this technique makes the Kelsh plotter a more efficient stereo triangulation instrument.

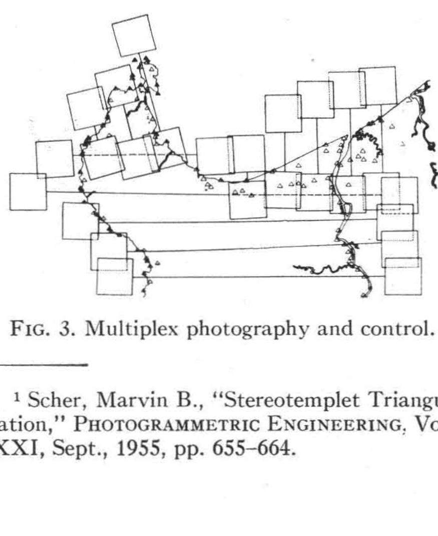

FIG. 3. Multiplex photography and control.

[1] Scher, Marvin B., "Stereotemplet Triangulation," PHOTOGRAMMETRIC ENGINEERING, Vol. XXI, Sept., 1955, pp. 655–664.

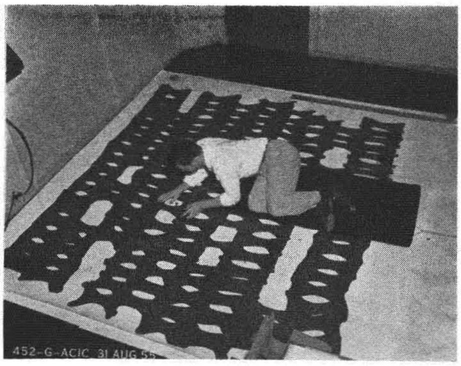

FIG. 4. Stereotemplet assembly.

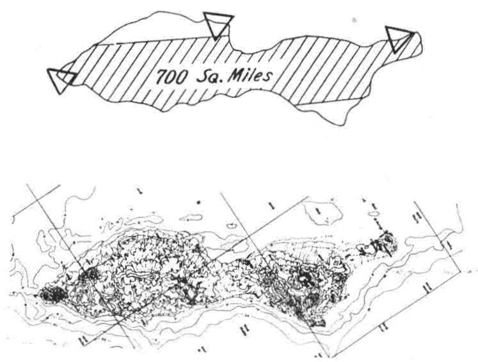

FIG. 6. Stereoplanigraph compilation.

Figure 5 shows the latest development in the Kelsh plotter—an attachment for accommodating obliques tilted at approximately 60 degrees. This particular instrument has not yet been used for medium-scale charting since the required service tests have not been completed.

Figure 6 illustrates an area for which 20 meter contours were required. The only available photography was a single flight of trimetrogon photography, with vertical scale of approximately 1:40,000. To accomplish this assignment, the Zeiss C-8 Stereoplanigraph was used with diapositive plates prepared from the paper prints available. It was impossible to completely parallax the models, but the results were accurate enough to classify the 20 meter contours as reliable. The cross-hatched area in the top half of this figure represents the area of vertical coverage; the lower half shows the completed compilation and some fathom lines adjacent to the island.

Although stereo compilations similar to those just described are somewhat standardized, they can become a challenge when adapted to unusual photography or control that just happens to be available.

Frequently compilations involve a combination of photo revision and trimetrogon techniques. Figure 7 illustrates the source maps available for a particular chart and the extent of vertical coverage of trimetrogon photography available for the same area. Control available is also illustrated. Approximately one-half of this chart is covered by 1:10,000 scale source maps.

To accomplish assignments of this type

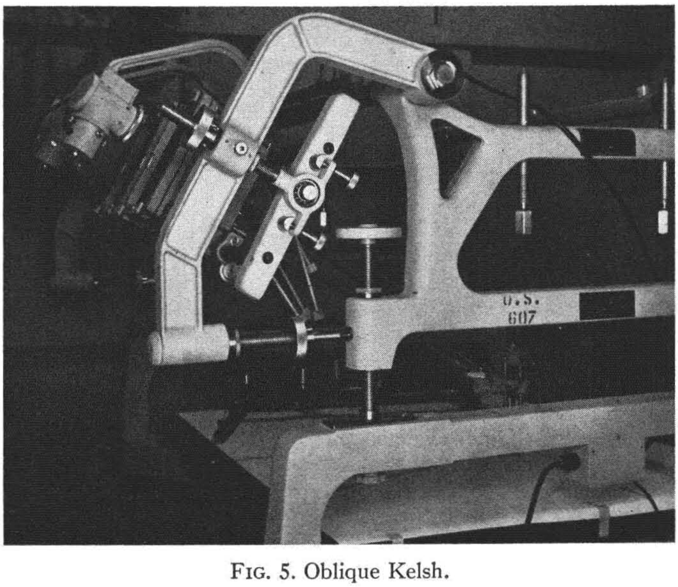

FIG. 5. Oblique Kelsh.

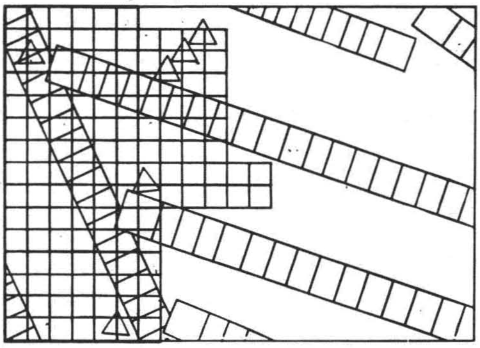

FIG. 7. Photo revision-trimetrogon compilation.

the large-scale source maps to be revised are paneled to the projection upon which the metal templets will be assembled. If the maps appear to be correct, the metal assembly is tied to well-defined points on the perimeter of the map series. Subsequent operations include the compilation or revision of detail through the use of Sketchmasters.

Figure 8 shows a 1:250,000 scale point base completed by use of slotted templets in the area of vertical coverage, and metal templets in the remaining area covered only by trimetrogon photography. Detail was compiled from the verticals by Ryker-Mahan plotters and from the obliques by Sketchmasters. Relief was sketched using vertical control established by the photoalidade or extracted from existing source maps.

Figure 9 illustrates a problem frequently associated with medium-scale charting and sometimes assigned as a special project; the challenge is to verify questionable elevations. In this particular case, the questionable elevation was verified from two existing flights of trimetrogon photography by means of the Air Force photoalidade. The first step in elevation determination by means of the photoalidade consists of computing the flying height from which the photography was exposed. The left obliques of flight #1 were used for this purpose, and computations indicated that the flying height was 2,000 feet beneath the recorded flying height. Further computations indicated that the map elevation was correct. To check this computation, the opposite obliques of the same flight overlooking the coastline were leveled, and an identical flying height was obtained. This would normally satisfy a photogrammetrist, but to further verify these findings, an independent set of computations was made from another flight and an almost identical elevation was obtained. This type of assignment is always welcomed by photoalidade operators since unique and interesting control problems are often encountered.

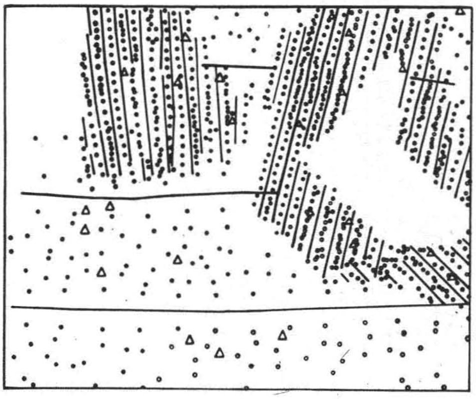

FIG. 8. Slotted templet-metal templet point base.

The photogrammetric procedures described herein represent, in part, the procedures adopted by the Aeronautical Chart & Information Center to meet the challenge of medium-scale charting. It is hoped that this brief review of problems and techniques will be both informative and useful to other who have similar challenges.

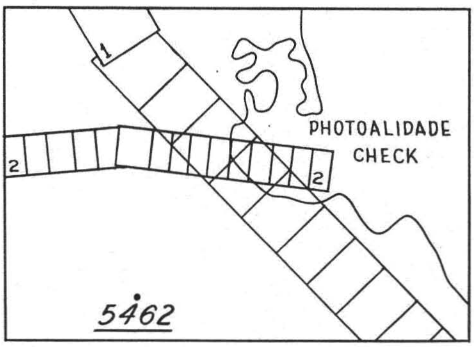

FIG. 9. Elevation verification.