TWO ENGINEER BOARD DEVELOPMENTS IN PHOTOMAPPING EQUIPMENT

J. T. Pennington

THE two Engineer Board developments in Photomapping equipment, which are to be discussed briefly in this paper, are instruments designed for use in the compilation of planimetric charts and medium scale topographic maps from the high oblique photography of the trimetrogon system. These instruments are: the high oblique multiplex projector and the rectifying projection camera.

It is well known that the trimetrogon system was developed for use in the compilation of small scale reconnaissance maps and aeronautical charts and for this purpose it has made a remarkable contribution to the charting program carried out during the war. In the preparation of small scale charts, the system is quite efficient and gives good results. However, in any field of endeavor, a tool or a method which is suitable for one purpose is not always suitable for another. While the trimetrogon system with present methods and equipment used in chart compilation is satisfactory for small scale planimetric charts, it is not entirely suitable for the compilation of larger scale topographic maps.

The adoption of the trimetrogon camera by the Army Air Forces for photography for Aeronautical charting, and the extensive amount of this photography made available by this program, indicated that Engineer Topographic units must be prepared to take maximum advantage of this material. It was early realized that it was very likely that large scale maps would be required in many areas in which there was trimetrogon coverage available and where it would be impossible, for various reasons, to obtain more desirable vertical photography. Hence, the Engineer Board was directed to develop methods and equipment both for exploiting the trimetrogon photography to the maximum, in the compilation of original aeronautical charts and strategic maps, and for the revision of all types of maps and charts. This development was to be divided into two phases with respect to the type of using organization; first for General Headquarters Topographic Battalions and base plants, and second, for Army Topographic Battalions, Corps Topographic Companies, and Aviation Topographic Companies.

In the first phase of this development, the possibility of employing the standard vertical multiplex equipment was investigated. This investigation resulted in the adaptation of the vertical multiplex for high oblique compilation. A simple bracket or adapter was designed, such that the vertical projector could be tilted to project at an angle of 60° from the vertical and which could be attached to the projectors without any alteration or machining necessary on the multiplex projector itself. With this adapter, all the translatory and rotational motions of the projector were preserved. This adaptation gave quite satisfactory results and afforded a means of continuous plotting in orthographic projection and for quite accurate contouring.

The accuracy obtained in test models set up and checked against ground control far surpassed our expectations as we had been somewhat dubious of the results that would be obtained due to our previous experience with the oblique multiplex designed for use with the oblique photography of the T-3A camera. The indications were that out to the principal points in the obliques, there was sufficient accuracy in the individual models for the production of 1 inch to the mile maps with a 50 ft. contour interval from 20,000 ft. photography. It is questionable, however, whether it would be possible in all cases to identify in

the obliques all the detail that should be shown on a map of this scale. Beyond the principal point the accuracy decreased somewhat and as the definition in the model became quite poor in this portion, only very prominent terrain features such as lakes, rivers and shore lines could be plotted faithfully. Of course, much detail was also masked out by the terrain.

We attributed these favorable results to the fact that in this country we have gained considerably in the last few years in "know-how" in the manufacture of aerial cameras and the multiplex equipment, and to the variable ratio reduction printers we now use with the wide angle multiplex. There is also, of course, some increase in accuracy due to the geometrical advantage of wide angle over normal angle photography.

While the results obtained with this adaptation were quite satisfactory, it was not considered a complete solution to the problem as it was quite awkward to operate, all the motions on the projectors did not function as they would if properly designed for the purpose, and the optics in the vertical projector are such that some definition was lost in the portions of the model near the line of flight as well as in the areas far out beyond the principal point.

The Engineer Board has therefore placed a development contract with the Bausch and Lomb Optical Company for the development of a High Oblique Wide Angle Multiplex Projector, which will be of proper mechanical design and with the optical design such that the plane of optimum focus will be horizontal. The design of the projector is such that it may be used with the present standard vertical multiplex auxiliary equipment; frames, reduction printers, etc.

Preliminary tests with pilot models of these projectors indicate that they will afford a means of fully exploiting the basic data contained in the trimetrogon photography, meeting in every respect our objective in this development. It appears that the accuracy of plotting will be limited more by the lack of calibration data on the aerial cameras used in obtaining trimetrogon photography than by the multiplex equipment itself and that there will be more than adequate accuracy for compilation of maps which are to be published at scales consistent with the amount of detail which may be identified in the high oblique photographs. In tests with these projectors at the Engineer Board, we have plotted a 40 ft. contour interval from 20,000 ft. photography out to a point in the oblique models approximately 70° from the vertical or the equivalent of about one inch above the principal point in a 60° oblique. Checks have shown these contours in the main to be accurately plotted within $\frac{1}{2}$ a contour interval, except, of course, in those portions masked out by relief.

In the second phase of this development, our efforts have been concentrated on the development of a rectifying projection camera, by means of which the trimetrogon photographs could be rectified, with the idea in mind that the photographs could then be handled in compilation in somewhat the same manner as were the photographs of the multiple lens T-3A camera, now obsolete. There is this important difference, however, in that this rectifier is adjustable so that true rectifications are made within the accuracy with which the tilt can be determined from the horizon or by other means. It will be remembered that each T-3A camera had its own specially constructed fixed angle transforming printer for the wing photographs which restituted the wing photos to the plane of the vertical chamber, and that the restituted assembly still contained distortions due to tilt of the camera at exposure.

An instrument was constructed at the Engineer Board in 1943 which would accomplish these rectifications. This instrument was thrown together in haste to serve as a test instrument for trying out our ideas and to serve as a basis

for setting up military characteristics of an instrument suitable for use by military units, should our investigation indicate sufficient merit to warrant further development. This instrument was designed, not only to rectify the trimetrogon photography, but as well the 9″×18″, 24″ focal length photography with tilts up to 42° and 9″×9″, 12″ focal length photography with tilts up to at least 30°. It was constructed so that almost any lens could be mounted in the instrument for test in making the required rectification.

It is a horizontal projecting type instrument with the negative, lens and vacuum easel supported in vertical planes on a horizontal bed, and has provision for canting the negative, lens and easel; for translation of the lens and easel along the horizontal bed; and also provision for swinging the negative in its own plane to any desired orientation. It is of very simple construction with scales, circles and verniers on all motions for accurate setting to computed data. No new principles of rectification are involved; it is simply an application of the old familiar principles of rectification by projection through a lens.

For the rectification of the high obliques we used a $4\frac{1}{2}$ inch focal length, f:18, Bausch and Lomb Protar Series V lens as this lens was immediately available from stock and covered the necessary angular field. For the rectification of the near vertical photographs we used a Goerz Apochromat Artar f:9.5 of $10\frac{3}{4}$ inch focal length. Illumination consisted of a bank of fluorescent tubes which was quite satisfactory although a little slow for the high oblique rectifications with the lens used.

With this instrument, quite satisfactory one step rectifications of the high oblique photographs have been made, when it is considered that the lens used was not designed for this special purpose. The rectified prints are quite sharp out to about 70° from the vertical and beyond this point the definition falls off but the prints have been used in test compilation out to about 75° from the vertical. Distortion in the photographs was negligible for the purpose intended, out to the principal point of the oblique, with the distortion running up to about 3 mm in the extreme background areas. It was very nearly radial from the plumb point so that it had a negligible effect on slotted templet extensions.

Various tests have been conducted to determine the possibilities and limitations of the use of this instrument in map compilation and map revision. Although these tests have not been extensive, they have shown that the use of rectified trimetrogon photography is at least a partial realization of our objective in phase two of this development. In these tests, slotted templet extensions of control have been made at scale of 1:40,000, making the templets directly from the rectified photographs; test compilations have been made from the prints to the slotted templet control; and some tests have been made in small scale planimetric chart compilation directly from shingle mosaics of the rectified prints and contouring or form lining from the rectified prints using the stereocomparagraph.

These tests indicate not only an increase in accuracy both geometrically and in quality and quantity of detail delineated, but also that some saving in time required in compilation of certain types of maps and charts can be affected using rectified photography.

Based on experience with this test instrument, we have procured two pilot model rectifiers made to our requirements which are now being tested. These instruments have specially designed $4\frac{1}{2}$″ focal length wide angle lenses for the rectification of the high oblique photographs and they also are supplied with lenses of about 8 inch focal length for the rectification of the near vertical photography. They are designed with special attention to light weight and portability

and may be easily broken down and packed in several carrying cases for transport. With these instruments, 9×9 6″ focal length photography with tilts up to 70° may be rectified with an isoline magnification range of from 0.9 to 1.1, 9×9 6″ and 12″ focal length photography with tilts up to 20° may be rectified with an isoline magnification range of from 0.6 to 2.5.

It is intended that the use of these rectifiers will not be limited to trimetrogon work but that they will also be valuable in mosaic compilation thus serving a dual purpose.

In conclusion, I would like to say that while we feel that the oblique multiplex offers a means of fully exploiting the trimetrogon oblique photography and that the rectifying camera is a valuable aid in exploiting the trimetrogon photography, we do not wish to leave the impression that we believe these developments will in any way obviate the use of vertical stereoscopic photography in the compilation of large scale topographic maps. There are certain definite limitations inherent in oblique photography which severely limit their application in such projects, such as, inability to identify and delineate detail in the obliques due to the increasingly small scale in the distant areas of coverage, the masking of detail by relief and vegetation, and the geometrical weakness of resection and intersection in the oblique coverage.