for oblique trimetrogon photographs presented in a report at the Congress at The Hague, that pairs of rectified oblique photographs could be used stereoscopically. He supplied the basic ideas that accuracy is a function of the accuracy of performing rectification of the obliques to a horizontal plane: in practice, it gives a correct planimetric rectification as far as the principal point of the oblique photograph and an altimetric rectification giving in a sense the relief valid locally with a correct equidistance of horizontal sections.

The same report gives first the geometric principles that guided the construction of the apparatus; it discusses how these geometric principles were used in practice, in particular how the stereoscopic relief effect of elevated objects was exaggerated four times.

It told also of the apparatus for viewing the photographs and concludes in indicating with interest what the instrument can offer for the rapid compilation of a provisional survey at 1/100,000, for example, in regions where the coverage with vertical photographs is insufficient to use ordinary mapping methods.

USE OF THE KELSH PLOTTER

by

Harry T. Kelsh, Photogrammetric Engineer.

The advantages and limitations of the Kelsh type of double projection plotters and a resume of the applications of the instrument by various governmental and commercial organizations.

All types of plotting instruments used in compiling maps from aerial photographs are designed to furnish a means of setting up a three dimensional model representing a portion of the earth's surface, using as data the overlapping part of two successive aerial photographs and means for graphically recording any desired data appearing in the model.

Since all plotters are designed for the same general purpose, then, within the limits set by our needs, or within the limts set by the quality of the data we must use, comparative economic evaluation of the results is more important than comparison of types of instruments based on personal preference. Such economic evaluation necessarily must take into consideration the original cost, the complexity of the instrument, for certain uses its portability, and relative operator training time necessary to permit the securing of satisfactory results.

There is no question as to the excellent degree of accuracy attainable with well constructed plotters of the optical train type in the hands of skilled and experienced operators. But to date, the good features have been accompanied by considerable complexity of design, lack of portability, and considerable cost. Operator training time is usually conceded to be longer than on projection type instruments.

The double projection type plotter is much more simple in construction. It can be made reasonably portable. It is easier to use, and it is much less costly to manufacture. Is is not as flexible in operation in that ordinarily it does not

permit material variation in the scale of the image it produces. The scale of the model is usually the maximum that other considerations, in the design of the instrument, will permit.

Apparently neither type of plotting equipment has reached its performance peak. Many new, and according to the advertisements, improved models of the optical train plotters have appeared on the market within the last year, and it is quite likely that the near future will witness similar changes and improvements in the projection plotter field.

The first generally accepted projection plotting equipment using miniature diapositives certainly offered no challenge to instruments of the other type on the basis of attainable accuracy alone; but other factors including cost and possibility of mass production so outweighed any such deficiency, that these instruments became firmly established in the field of photogrammetry throughout the world. The many things that were learned through use offered a splendid base for the subsequent development of the Kelsh Plotter.

The Kelsh Plotter uses full scale diapositives that may be printed by contact, thus eliminating the need for an expensive printer. The lighting system is designed to concentrate all its light on the small area of the platen of the tracing table, the light following the tracing table automatically as it is moved. This development made it possible to reduce both the aperture of the projection lens and the size of the illuminant. The result is plenty of light, considerable depth of focus (one of the weak points in projection apparatae), and no heat problem.

The light guiding arms furnish a means of working an automatic corrector for lens distortion, either of the taking lens or the projection lens. By suitable mechnical linkage the projection lens moves along its vertical axis, thus increasing or decreasing the distance between the diapositive and the lens. While such simple correction method is not 100% theoretically correct, the amount of error, within the range of the instrument, does not reach the point of limit of visual perception, and in practice the device has been very satisfactory indeed.

Factors for earth curvature may also be included in the correction device. This feature is of increasing importance as our data is secured from higher and higher altitude.

The instrument, without alteration, may be used with convergent photography up to 20-25 degrees, and a model for use with trimetrogon wing photographs is in development.

Considerable increase in flexibility was secured by adding a pantograph. As designed, this permits only reduction from the model scale.

Means for recovering the tip and tilt of either of the pair of diapositives, by use of level bubbles, make it possible to use the Plotter for extension of horizontal and vertical control.

Now the features that have been mentioned definitely represent improvement in this type of plotter, but just how much improvement it is surprisingly difficult to assess.

The instrument has been accepted by practically all the large mapping organizations in the United States of America, both commercial and government, including the military. But the results of military tests are necessarily restricted and those of competing commercial concerns are, as might be expect-

ed, trade secrets. The government agencies have each adapted the instrument to particular needs, often to fit into programs based on previously purchased equipment. The United States Forest Service uses the Plotter mainly as a means of reducing field control cost, finding it advantageous to fly each area twice; the first set of photographs being taken at as high an altitude as will still permit accurate determination of spot heights when the data is placed in the Kelsh Plotter, and doing the actual compilation with the second set of photographs, taken at lower altitude, in other and still less expensive plotting equipment.

The Department of Agriculture is using the instrument because of the large size of the projected model, and the quality of model definition to more accurately sketch close-interval form lines.

The Geological Survey has integrated the use of the Kelsh Plotter with the Multiplex, often using both instruments in a single area, reserving the Kelsh for the less steep terrain.

The Trimetrogon group, in the same organization, largely engaged in small scale and reconnaissance mapping, base their opinion of the capabilities of the instrument upon the superior definition which enables them to get the most out of even very substandard photography.

Test results in the various government agencies are slowly accumulating, and in time will furnish a basis for an accurate appraisal of the various features of the Kelsh Plotter; but in the meantime, it is felt that the excellent reputation which the instrument has achieved has been reasonably well deserved.

NOTE

In the following article, "Proposed Standard Test of Stereoscopic Plotting Instruments," the word "wide" should be inserted between "with" and "angle" in line 17 on page 3.