MECHANICAL INSTRUMENTS FOR PLOTTING FROM OBLIQUE PHOTOGRAPHS*

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THE compilation of planimetric maps from Trimetrogon photography in the Geological Survey has included the use of several instruments which facilitate the application of the oblique photographs to a graphic triangulation process. The foundation of these instruments is a mechanical linkage which operates in a single plane to accomplish the projection of photographic angles as measured at the photograph nadir point into equivalent horizontal angles as measured at the ground nadir point. The forerunner of this class of instruments was the Rectoblique Plotter (previously described in *The Manual of*

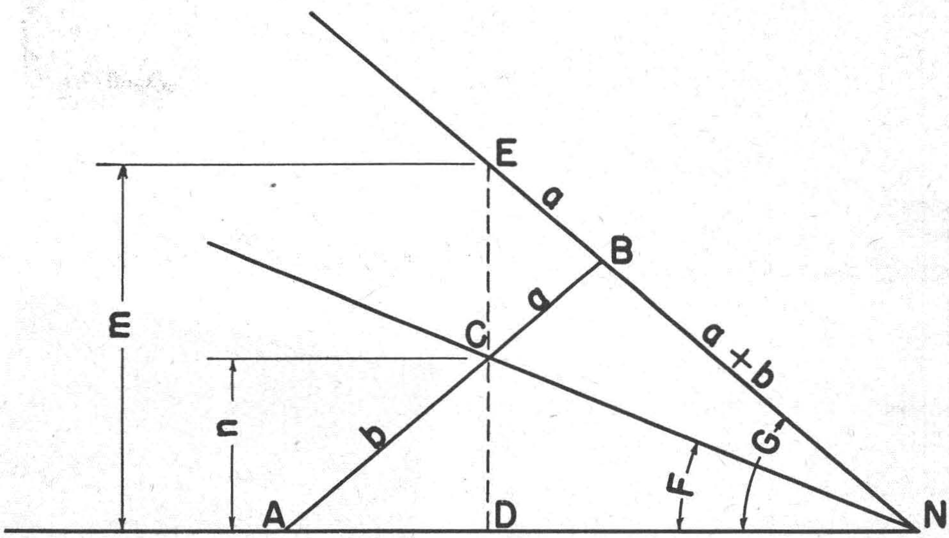

FIGURE 1

Photogrammetry) which was originally designed in the Survey in 1941. Rectoblique Plotters have been used continuously for four years to prepare paper templetes, recording the horizontal radials to points on the oblique photographs. The application of the Rectoblique linkage to Photogrammetry is rather obvious since the lineals and pivots all have counterparts in an elementary geometric treatment of the oblique. Many combinations of lineals can be found which give the solution to this problem, the only real task being to find the simplest and most practical. A very simple arrangement is shown geometrically in Figure 1 in which AN, CN and EN are any three lines forming angles F and G and N. Point B on EN and A on AN are located so that

$AB = BN =$ any convenient length

DE is perpendicular to AN through C on AB

$$\tan G = \frac{m}{DN}; \qquad \tan F = \frac{n}{DN}\cdot$$

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Therefore

$$\frac{\tan F}{\tan G} = \frac{n}{m}. \tag{1}$$

Since angle BAN = angle G

$$\sin G = \frac{n}{b} = \frac{m}{EN} = \frac{m}{EB + a + b} \tag{2}$$

$$\text{Angle } ACD = \text{Angle } ECB = (90 - G)$$

$$\text{Angle } BEC = (90 - G) = \text{Angle } ECB.$$

And

$$EB = CB = a.$$

From (1) and (2)

$$\frac{n}{m} = \frac{\tan F}{\tan G} = \frac{b}{2a + b}. \tag{3}$$

Now if point C is fixed on AB and BN revolves about N with A on AB free to move along AN, then tan F/tan G is constant for all values of F and G. The value of this constant can be made to vary from 0 to 1 as C is moved to various positions from A to B.

Now let AN be the principal line of a photograph with N the photograph nadir point. From the geometry of a tilted photograph the equation

$$\frac{\tan F}{\tan G} = \cos t \tag{4}$$

can be established;
where

F = Angle at photograph nadir point between the principal line and any photographic image.

G = Equivalent horizontal angle at the ground nadir point.

t = Angle of tilt of the photograph.

From (3) and (4) it is evident that point C can be located on AB so that

$$\frac{b}{2a + b} = \cos t$$

for any value of t from 0° to 90°. Thus AB can be graduated directly in degrees of tilt from 0° at B to 90° at A.

It should be noted that the solution is limited in practice by the accessibilty of the point N, which recedes to infinity when $t = 90°$. A linkage built on this principal will be found practical for all photographic tilts from near verticals to high obliques with depression angles not less than approximately 20°.

The Photoangulator (Fig. 2) was built from the geometric principal of Figure 1. This instrument consists of two arms revolving about the photograph nadir point, one of which carries an inscribed line and moves over the photograph while the second arm or blade moves over the template or map and is used as a straight edge for drawing radials to points determined by the inscribed line. The lineal connecting the two arms is graduated in degrees of depression angle and carries an adjustable pivot for setting to the desired angular value.

The Photoangulator was constructed primarily for use on the map manuscript to intersect secondary photographic control points or detail points, immediately following the main adjustment of primary photographic control obtained with slotted templets. These instruments have proved valuable where it was necessary to intersect a great number of detail points for controlling the sketching of planimetry with the oblique Sketchmaster.

The Stereoblique Plotter, Figures 3 and 4, was developed to draw planimetry from overlapping oblique photographs in orthographic projection. A number of

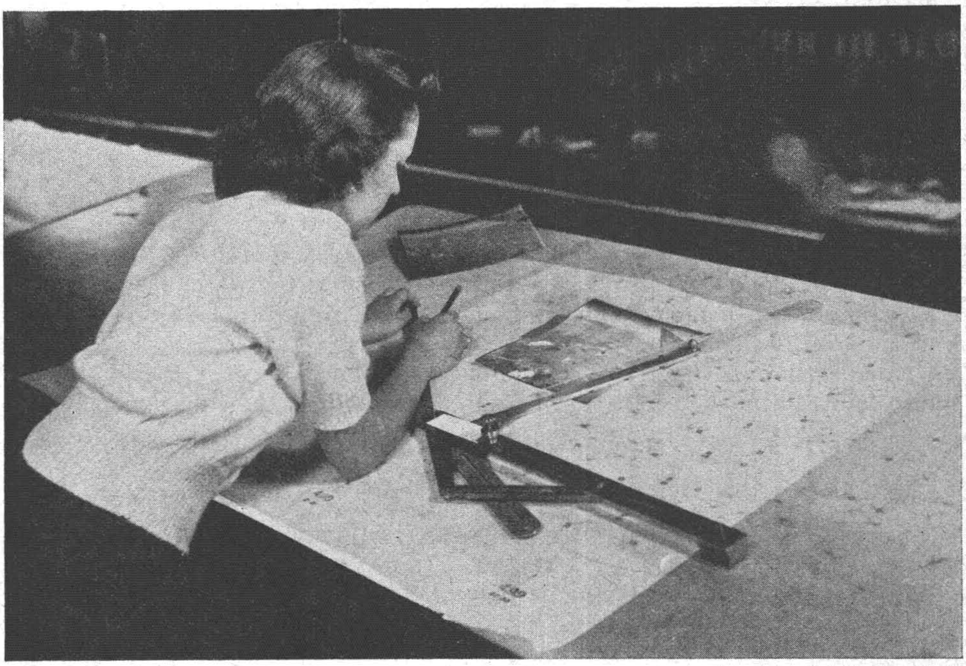

FIG. 2. Intersecting detail points with the Photoangulator.

these instruments have been constructed by the Division of Field Equipment of the Survey and have been in use for more than a year in the Alaskan Branch. The device is a stereoscopic plotting instrument containing two revolving index lines which combine in the stereoscopic model to form a vertical line piercing the ground at a definite point, the map position of which is determined by two revolving rods intersecting in a plotting pencil. The operator actuates the floating line by directly sketching with the pencil on the map.

The Stereoblique embodies two Photoangulator linkages to one of which is connected a parallelogram which transfers the motion of the linkage to an adjustable pivot near the nadir point pivot of the other linkage. Thus a linkage with a revolving transparent blade, carrying an index line, is provided for each of two overlapping photographs which are mounted on graduated plates in such a manner that the center of revolution of the blade will coincide with the photograph nadir point and the inscribed line will coincide with the principal line. Two rods revolve about the map nadir point pivots and engage a carriage which

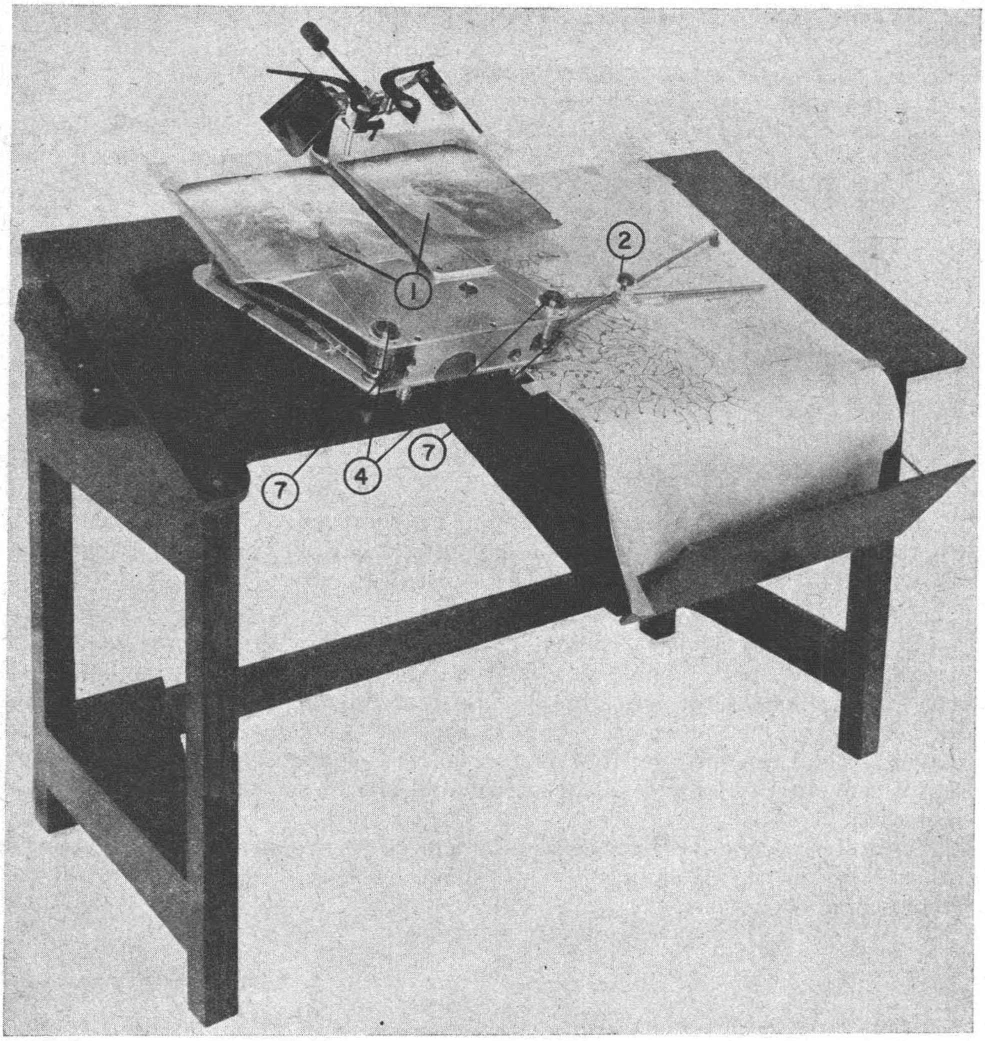

FIG. 3. The Stereoblique. 1, Index Lines. 2, Plotting Pencil. 4, Photograph Nadir Points. 7, Orientation screw.

contains the plotting pencil. Adjustments on the linkages provide for varying tilts and for orienting each photograph to the photographic control.

The tilt and swing of each oblique must be determined and the radial triangulation adjustment of photographic control must be made before the Stereoblique is used for planimetric mapping. A plotting scale range of 1/30,000 to 1/80,000 is possible when using consecutive photographs of six inch focal length taken at 20,000 feet. These limits are determined by the amount of adjustment provided between the two map nadir point pivots.

A unique type of stereoscope was designed for use with the Stereoblique and has since proved very popular in other photogrammetric applications. Since the overlapping oblique photographs must be mounted in the instrument in fixed predetermined positions, adjustments of the stereoscope rather than the photographs must be made in order to obtain stereoscopic fusion.

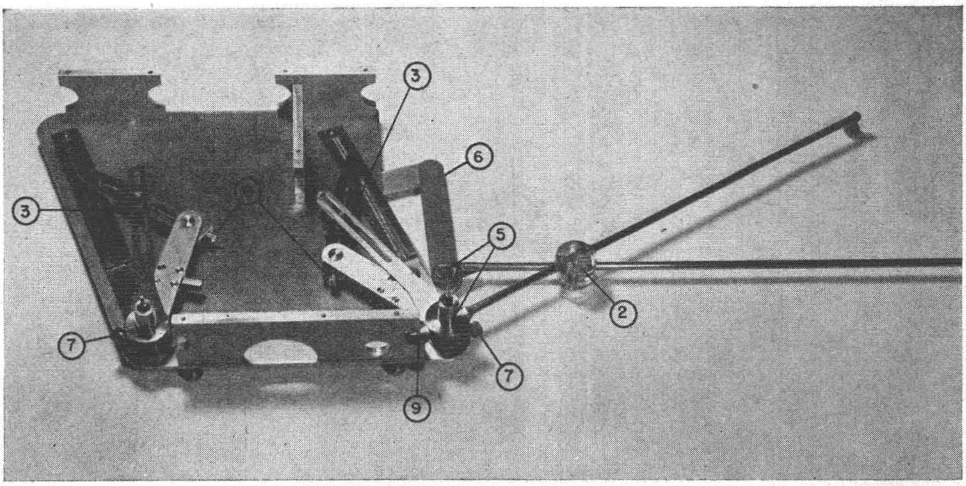

FIG. 4. The Stereoblique with top plate removed. 2, Plotting pencil. 3, Photoangulator linkage. 5, Map Nadir points. 6, Parallelogram. 7, Orientation screw. 8, Tilt adjustment. 9, Air base adjustment.

In the stereoscope two conventional front surface mirrors are combined with two right-angle prisms, the latter having rotational freedom about two axes for the purpose of providing an apparent movement of the photographs for best fusion. The inner prisms are rotated by two convenient handles which extend around the outer mirrors to the rear of the stereoscope. A plano convex lens is cemented to the face of each prism and provides a small amount of magnification.

This stereoscope has proved so practical in operation that it has replaced other types in the Alaskan Branch and is now being used in practically all stereoscopic operations.