COMMENTS ON THE MULTISCOPE

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THE article on "The Multiscope: A Simple Stereoscopic Plotter," by Stephen H. Spurr and C. T. Brown, Jr., in PHOTOGRAMMETRIC ENGINEERING, Vol. XI, Number 3, describes a device that is represented as permitting precise orthog-

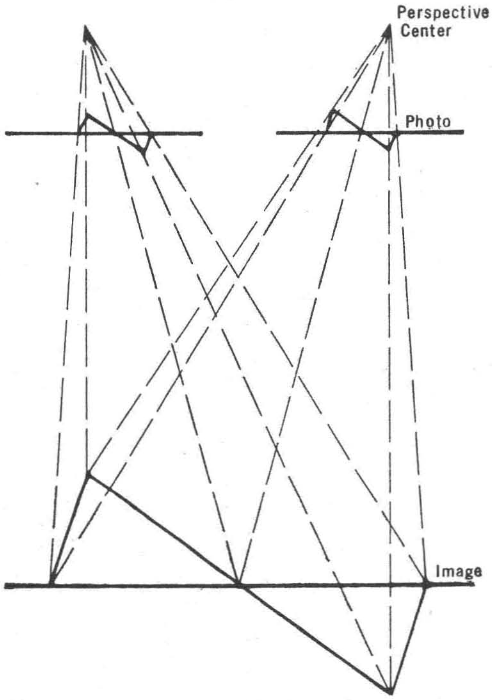

FIG. 1

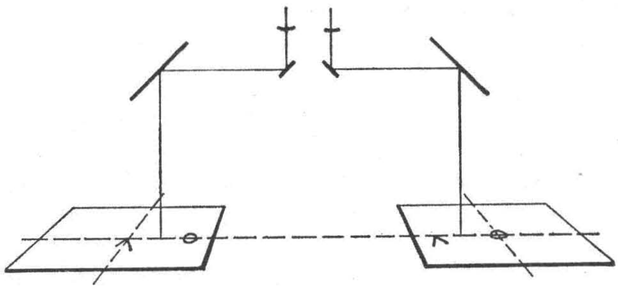

FIG. 2

onal plotting. It is the object of these comments to point out sources of inaccuracy in plotting with the Multiscope.

The diagrams used in the article indicate that the photographs are oriented under the mirrors so that identical image points midway in the overlap area are set at the base of the vertical axis of the eye piece and mirrors. See Figure 1.

If this is the intention of the designers, there is an error in theory, and the

Multiscope does not permit true orthogonal plotting, because the stereo image is not a true reproduction of the terrain as it was originally photographed.

The emergent bundle of rays of the camera lens had within it certain angular relationships, originating at the rear nodal point of the lens and terminating at the image points on the film. If a true projection is desired, the same angular relationships must be recovered. This can be done only by occupying the perspective center of each of the photographs. See Figure 2.

If there is movement from the optical axis so that the points of projection of

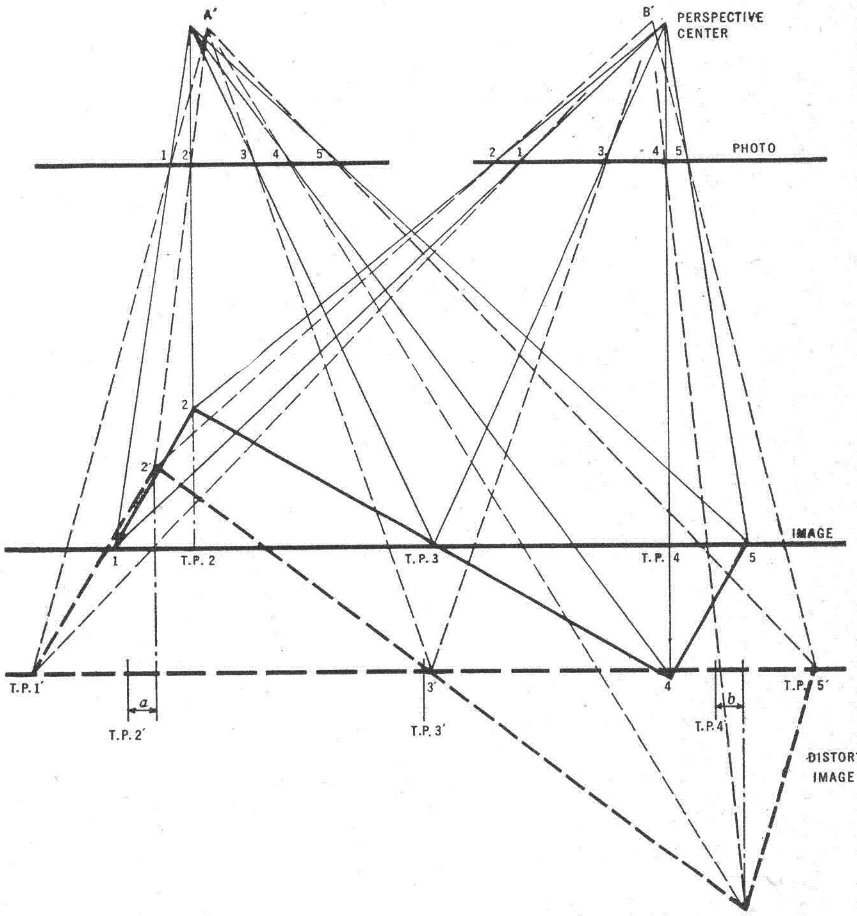

FIG. 3

the stereo model are not at the perspective centers of the two photographs, there will be distortion in the model. The original angles existing in the camera at the moment of exposure are not recovered. This is the source of one component of distortion in the multiscope. See Figure 3.

The dotted figure is projected from points *A* and *B* which are displaced from the optical axis. The horizontal position of points 2′ and 4′ are in error in this case by the amount *a* and *b*. Points 1′ and 5′ are considered to be in their true position at increased scale, with T.P. 2′, T.P. 3′, T.P. 4′ falling in their relative true locations between 1′ and 5′. These points have been located by merely enlarging the scale of the true image.

Figure 4 shows another component of distortion that exists in the Multiscope due to the use of rotating prisms. The prisms are used to bring the map surface into coincidence with the stereo image. The lines of sight from the eyes through the half silvered mirrors are bent by the prisms to make it possible to reference a single point on the manuscript to a point on each of the photo images that are seen on the mirrors. In Figure 4, *a*, *b*, *d*, *f* and *g* on the left and right photos are seen in stereo on the half silvered mirrors. By looking through the mirrors at a pencil or a movable dot as a reference, points *a*, *b*, *d*, *f* and *g* can be plotted by placing the points so they are in perfect register with the corresponding points on the stereo model. If "*d*" is brought into coincidence with the map surface,

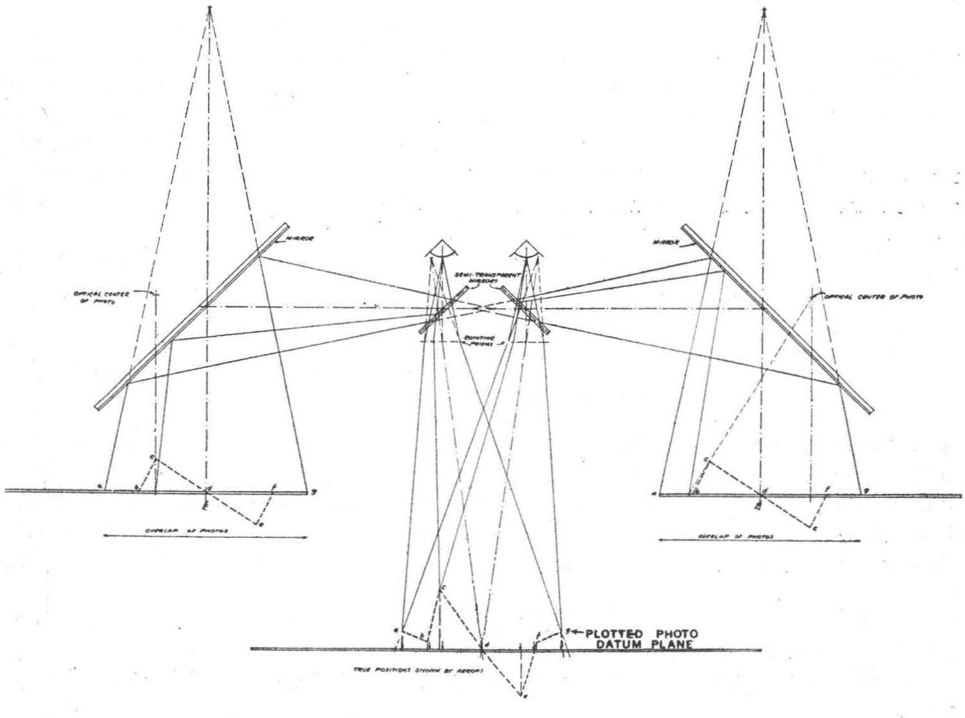

FIG. 4

points *a*, *b*, *f* and *g* will plot above the level of "*d*", forming a curved line labeled "Plotted Photo Datum Plane" in Figure 4.

The diagram cannot fully indicate the relationship between the stereo image and the reference map plane as it is seen by the operator when he looks into the stereoscope. The photo datum line *a*, *b*, *d*, *f* and *g* is seen in the mirrors as a straight line because the parallax measurements of each of the points is the same. The map surface seen in relation to this straight line appears turned down at the edges due to the bending of the rays through the rotating prisms. This can be visualized by checking the parallax of the plotted point "*a*" projected down to the map surface, shown by the arrowhead in the diagram.

Whether or not the distortion is an appreciable amount cannot, of course, be checked without working with the instrument.

The diagram shows an exaggerated case, drawn for the purpose of showing that if there is any bending at all through the prisms, there will be, theoretically, a lack of coincidence between the photo datum and the map reference plane.

There is another possible method of orienting photographs in the Multiscope. The photographs could be placed so that the optical axis of each photograph coincides with the vertical axis of eyepiece and mirrors. In this arrangement, each eye is over the exact center of the photograph being viewed, and the stereo image is seen by converging the eyes. No prisms are necessary to see both the map and the true stereo model.

The weakness of this arrangement is the limitation to plotting scale. The plot, if it is to be an orthogonal projection, will be at the scale: (interocular distance/air base distance) no matter how the principal distance is varied. The air base distance in any one particular run can have wide variations, depending the variation of overlap at one scale. Standard specifications allow overlaps ranging from 55 to 65%. This variation is evidence of changes in air base distance which will cause variations in plotting scale for adjacent pairs of photographs.

It may be that the designers of the Multiscope had certain purposes in mind that do not require original plotting or map making as such, but rather sketching or delineating special information on the framework of a base map already made. If this is the case, the instrument can fulfill these limited purposes, because accurate plotting is not neceesary.

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IN PHOTOGRAMMETRIC ENGINEERING, Vol. XI, No. 3, of September 1945, a description is given of the "Multiscope." On page 173, it is stated that an "orthogonal plot" can be obtained when semi-transparent mirrors are used. Reference is made to Figure 2. This statement is true, but under certain conditions only; therefore, the conditions under which this "orthogonal plot" can be obtained might be investigated.

Supposing that there are two exactly vertical photographs with equal flying height (and equal focal length) these conditions are:

1. Virtual images of photographs must be parallel to virtual image (V.I.) of map.

2. Left (right) eye perpendicularly above principal point of V.I. of left (right) photograph, when "perpendicular" means with reference to V.I. of map.

3. Distances of left (right) eye to the principal point of V.I. of left (right) photograph must be equal.

With eye is meant exactly the center of the sphere of the eye which is the center of projection. If the above conditions, of which the third is more or less self explanatory, are fulfilled, then the distance of the principal points on the map is always equal to the distance of the eyes of the observer, therefore, the scale of the map is a fixed quantity, equal to (eye base/air base).

This eye base can be influenced by a system of mirrors or plane-parallel glass plates—but more simply by the use of two measuring marks instead of one, which is the well known principle of the so called "parallogram of Zeiss."

If the rotary prisms are used as stated in the above-mentioned article, or if the observer changes the position of his head, then the places of the virtual images change and the result is not orthogonal.