Demonstration Board for
Stereoscopic Plotter Orientation

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ABSTRACT: *Inasmuch as instructors in photogrammetry frequently have insufficient plotting equipment for teaching the initial ideas of the procedure of relative orientation to a class of students, an inexpensively constructed board is described as a classroom visual aid. The device consists of a ferrous sheet cemented onto composition board for stiffness with red and blue colored magnets for demonstrating the effects of the five classical adjusting motions. As a result of a single demonstration, each student has a clear idea of the procedure before he starts to practice on an instrument, thus reducing the time needed on the instrument itself.*

A COURSE in Photogrammetry should include the basic principles of the orientation of stereoscopic plotters. The addition of a stereoscopic plotter would strongly augment the teaching of plotter orientation. But on the other hand the principles of how and why the sequences of relative and absolute orientation converge to form a true model is difficult for an instructor to explain and for the student to grasp.

A demonstration board for presenting plotter orientation was designed by the author who wishes to express his appreciation for the suggestions of Professor Francis H. Moffitt of the University of California at Berkeley who stimulated the idea.

The demonstrator consists of a metal board to represent the model and magnets for the images of points in the model. It is necessary to have the board large enough to be seen 10 or 15 feet away. It has to be set up vertically and the marks representing the images of points on the model to be used for orientation have to be large enough for good visibility.

The board is made from a metal blackboard which consists of a thin sheet of steel cemented to a $\frac{3}{8}$ inch thick piece of composition board. The dimensions of the board are 21 inches by 36 inches and those of the neat model are 15 inches by 30 inches. The board is painted white and the neat model is outlined in black (Figure 1).

The neat model consists of a $\frac{1}{4}$ inch wide dotted line with short cross bars at points 1 and 2 representing the location of the principal points. Black numbers one inch high are painted on the board to represent the six points of adjustment. A blue I is painted beside principal point 1 to represent the left projector and its color, and a red II beside

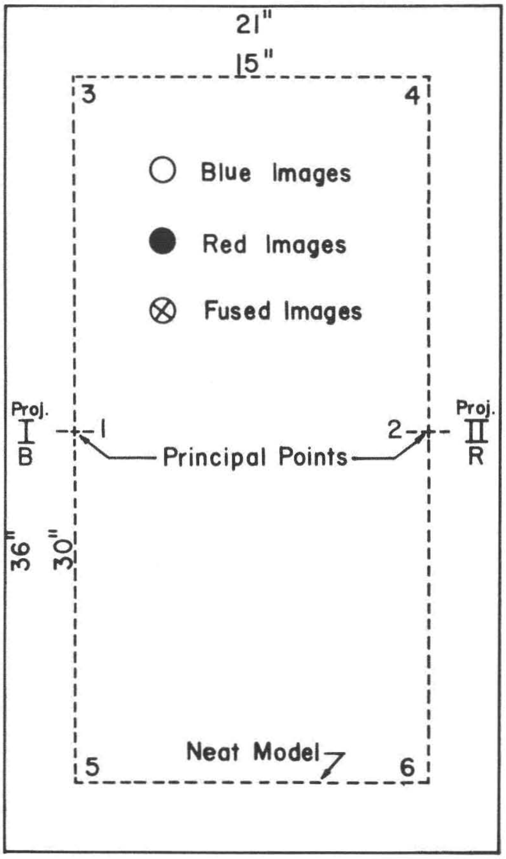

FIG. 1. Plan of orientation board and legend.

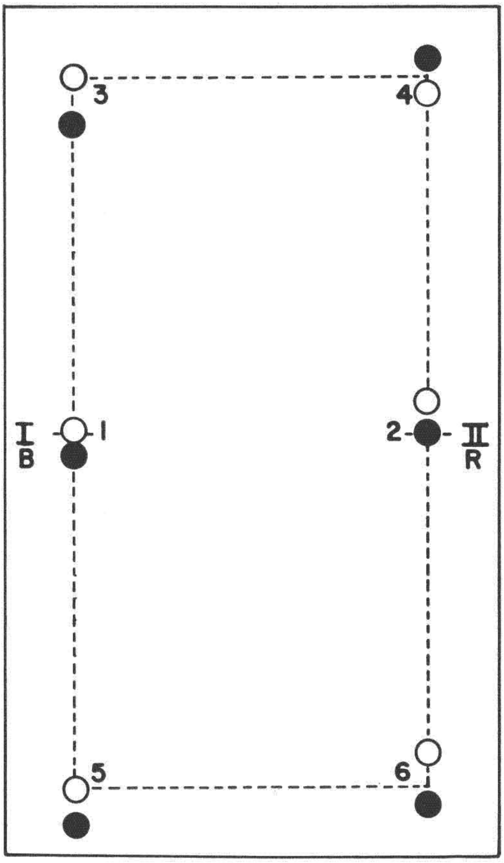

FIG. 2. Initial random distribution of magnets.

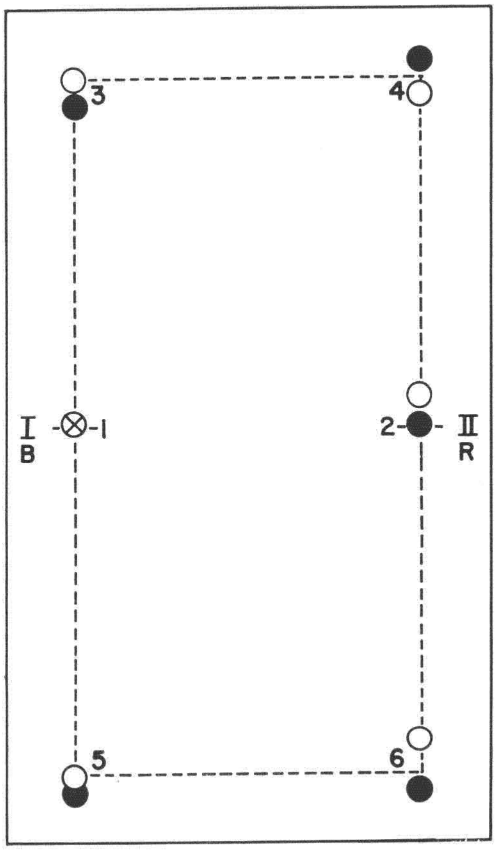

FIG. 4. Elimination of y-parallax at point 1 by κ motion of projector II.

principal point 2 to represent the right projector. A coat of dull varnish is applied for protection. Fourteen to twenty ceramic magnets, $\frac{3}{4}$ in. in diameter and $\frac{1}{8}$ in. thick, are used. Half of these magnets are painted red and the other half blue. The red magnets

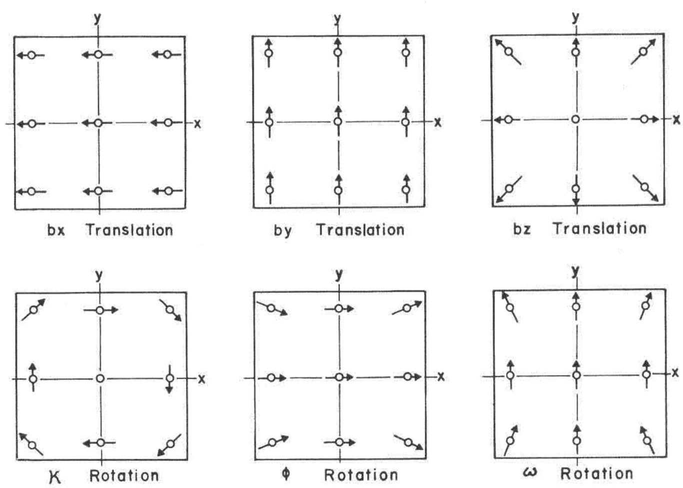

FIG. 3. Point movements caused by projector motions.

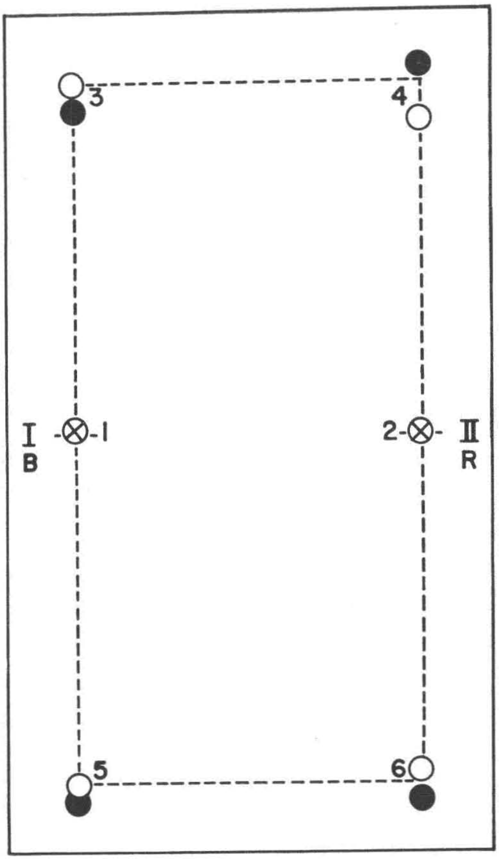

FIG. 5. Elimination of y-parallax at point 2 by κ motion of projector I.

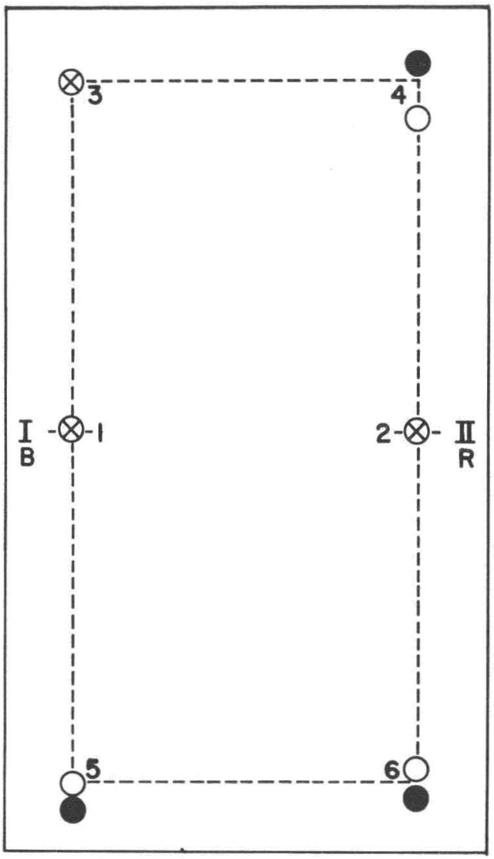

FIG. 6. Elimination of y-parallax at point 3 by ϕ motion of projector II.

represent the six points on the neat model projected from one picture and the blue magnets the same points from the other picture. It is well to have extra magnets to allow for breakage and loss.

The board is set up in front of the class and the red and blue magnets are placed at random with x-parallaxes eliminated leaving only the existing y-parallaxes (Figure 2). Sketches of the relative motion of points due to bx, by and bz translations and κ (swing), ϕ (y-tilt) and ω (x-tilt) rotations of a projector are drawn on the black board as shown in Figure 3.

For example, consider the relative orientation of the two projectors of a plotter having no bz or by motions. The y-parallax at point 1 can be cleared by ω motion of projectors I or II or by κ motion of projector II. The use of ω motion will affect all points in the model whereas the κ motion will leave points 2, 4, and 6 relatively unchanged while points 3 and 5 receive about the same y correction made at point 1. The results of κ motion of projector II can be seen in Figure 4.

The y-parallax at point 2 can be cleared by ω motion of projectors I or II but this will disturb the adjustment just made at point 1. Point 2 can also be cleared by a κ motion of projector I which leaves point 1 undisturbed (Figure 5).

The y-parallax at point 3 can be cleared by ω, ϕ, or κ motion of projector II or ω of projector I. The ω and κ motions will introduce new y-parallaxes at points 1 and 2 previously cleared, but ϕ motion of projector I will only affect points 3 and 5. The results of ϕ motion of projector II are shown in Figure 6.

Point 4 can be cleared of y-parallax by ϕ motion by projector I without introduction of y-parallax at points 1, 2 or 3 (Figure 7). Again ω or κ motions of either projector could be used but the previous adjustments at points 1, 2 and 3 would be disturbed.

If no y-parallax exists at points 5 and 6 the model is oriented; however, this rarely hap-

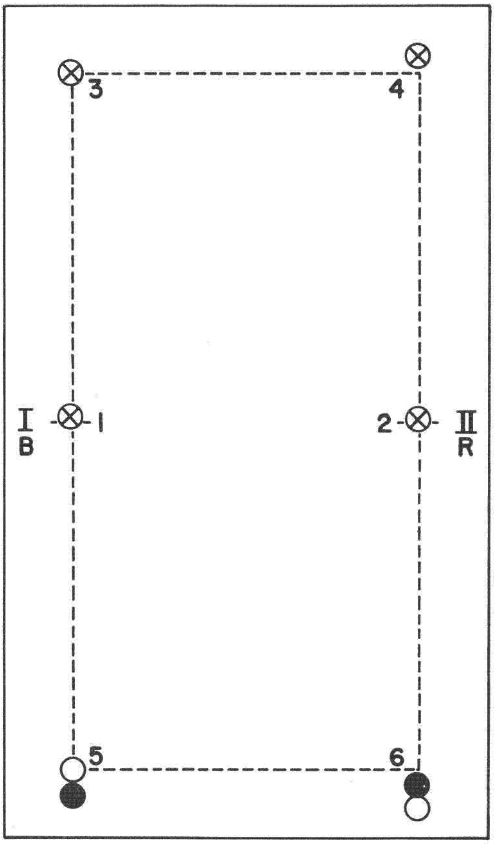

FIG. 7. Elimination of y-parallax at point 4 by ϕ motion of projector I.

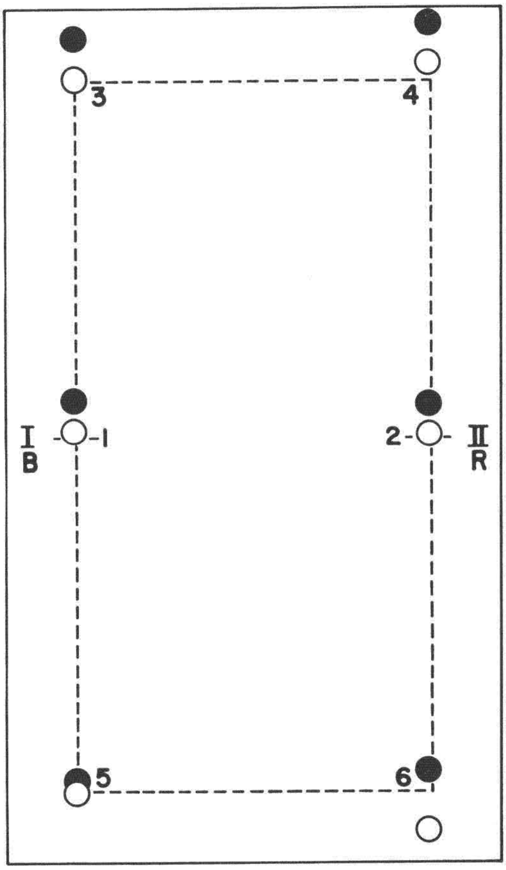

FIG. 8. Over correction of y-parallax at point 5 by ω motion of projector II.

pens on the first cycle. Since κ and ϕ motions of both projectors have already been used, only ω motions remain. The introduction of ω motion of either projector I or II to clear point 5 or 6 introduces a proportionate amount of y-parallax at all other points in the model. Since readjustment of points 1, 2, 3 and 4 will introduce y-parallax at point 5 or 6 in the opposite direction of the previous correction, the y-parallax at 5 or 6 is overcorrected by approximately $\frac{1}{2}$ the amount existing at point 5 or 6 before correction (Figure 8). The process is now repeated until points 5 and 6 are free of y-parallax.

A similar approach to the one just explained can be used now to demonstrate the absolute orientation of the model. It can also be used to demonstrate the orientation of one projector with respect to a fixed projector as is done in plotters capable of bridging control. The student should now have a good understanding of the effect of the projector motions on the stereoscopic model. If a stereoscopic plotter is available the student could then put to use these principles thus fixing them more firmly in his mind.

This demonstration board has been used for three classes of students in the Photogrammetry courses at Rutgers University. Through discussion with students following the use of this board it was found that the students' understanding of orientation principles far exceeded that of students in previous years who did not have the benefit of this teaching aid. The construction of the board as explained in the first part of this article is quite simple; it costs in the vicinity of $10 to build. It is believed that this can be an invaluable aid to those in other universities who are faced with the problem of teaching the principles of plotter orientation.

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