MAHAN PLOTTER*

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THE Mahan Plotter,[1] like the K.E.K. Plotter,[2] and the Multiscope,[3] is a simple stereoscopic mapping instrument designed to use ordinary 7″×9″ or 9″×9″ contact prints of vertical aerial photographs. Like these other instruments it is more elaborate than the Fairchild Stereocomparagraph or Abrams Contour Finder; it provides for plotting on a constant scale, and it provides approximate correction for tilt. On the other hand it is not as elaborate as the

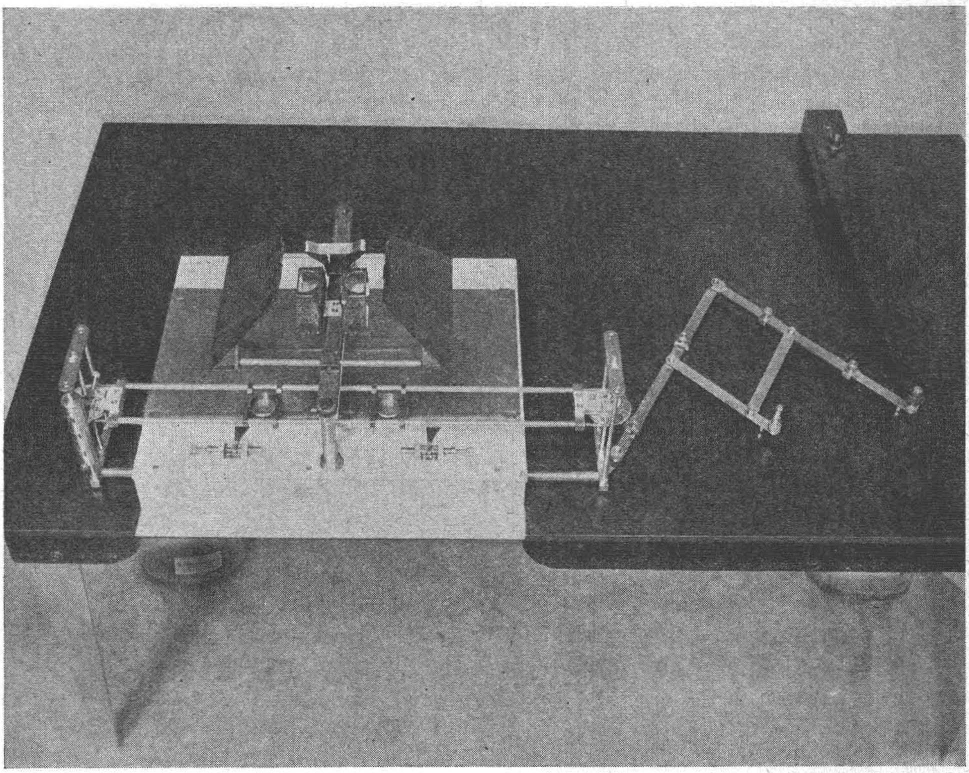

FIGURE 1

Multiplex, Stereoplanigraph, or equipment used in the Brock Process; it does not provide such refinements as correction for lens distortion. It is one of a rapidly expanding group of new instruments developed to meet the need for a simple, adaptable, low-cost, accurate plotter.

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[1] Richard O. Mahan, U. S. Geological Survey, designed and constructed the first two plotters in the Sacramento office of the U. S. Geological Survey in 1942 and 1943.

[2] The K.E.K. Plotter was described by J. E. King in PHOTOGRAMMETRIC ENGINEERING, Vol. X, No. 4, 1944, pp. 252–263.

[3] The Multiscope was described by Stephen H. Spurr and C. T. Brown, Jr., in Photogrammetric Engineering, Vol. XI, No. 3, 1945, pp. 171–178.

The Mahan Plotter is, however, quite different from other plotters in design, in the size and arrangement of its various parts. Even though its basic elements are the same as for the K. E. K. Plotter—a stereoscope, a floating mark, a pair of photo holders, and a pantograph—it does not resemble the K. E. K. Plotter in appearance. Two views of the instrument are shown in Figures 1 and 2.

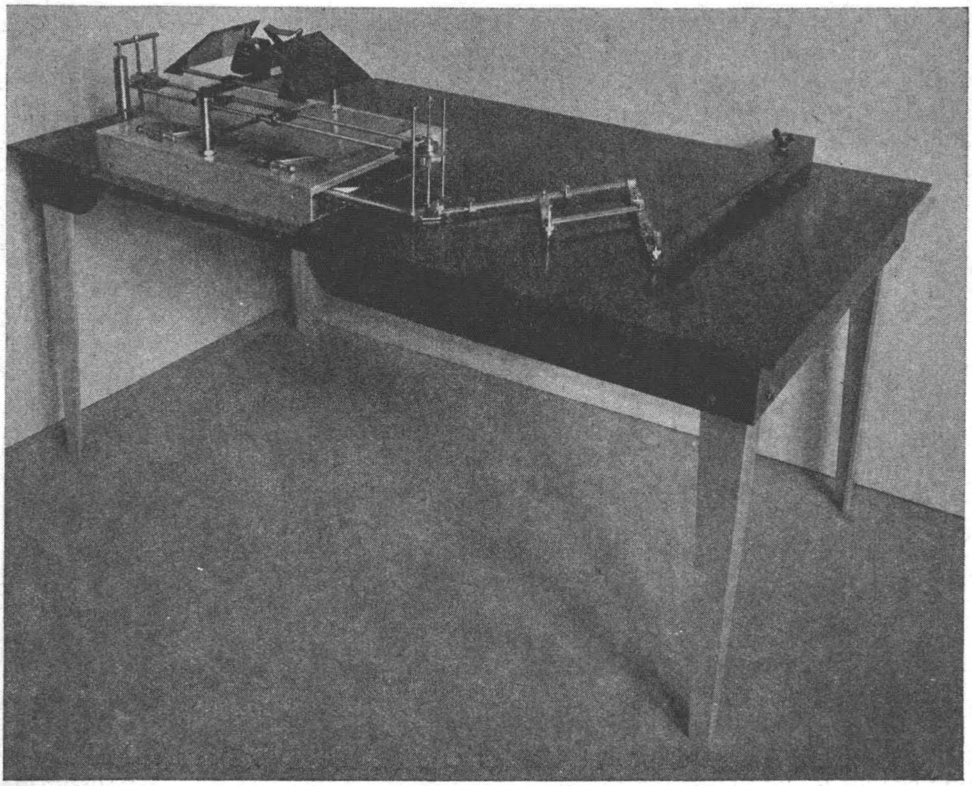

FIGURE 2

Stereoscope

The stereoscope of the Mahan Plotter resembles other mirror type stereoscopes in some respects. Front surfaced mirrors are used to eliminate ghost images, and the inner mirrors are mounted so that they can be easily adjusted to fit the eye base of the operator.

For correct performance, however, the stereoscope on any plotter such as this must meet several special requirements imposed by the geometry of the photographs:

(1) The lines of sight reflected from the inner mirrors must be in a common plane with those reflected by the outer mirrors, so the inner mirrors must be exactly parallel with the outer mirrors. To accomplish this condition the inner mirrors of the Mahan Plotter are provided with adjusting screws.

(2) The stereoscope must allow the operator to view the whole stereoscopic model from one base position. The stereoscope of the Mahan Plotter is not only held in position by rigid posts at the front and back of the base plate, but it

also allows the operator to hold his head in position by contact with the sides of his nose, by support for his forehead, and by visual marks on the lower edges of the outer mirrors. The mirrors themselves are unusually wide so that all edges of the model can be seen.

(3) To be theoretically accurate for tilted photographs the stereoscope should allow the operator to hold his eyes at the perspective center of the two photographs. For practical work on photographs tilted only one or two degrees the distance from the operator's eye to the photograph can be somewhat more than the principal distance of the photograph without causing appreciable errors,[4] but photographs tilted three degrees or more are common enough so that the operator must keep in mind the limitations of the instrument. A special effort was made to design the Mahan Plotter so that the operator's eyes would be 210 mm. ($8\frac{1}{2}$ inches) from the photographs. It is, therefore, theoretically accurate when used with common $8\frac{1}{4}$-inch photographs. When it is used with wide angle photographs extra control must be obtained and each stereoscopic model must be broken into small parts whenever a photograph is badly tilted.

Floating Mark

The floating mark lenses of the Mahan Plotter are supported above the surface of the photographs. The distance between the lenses and the photographs is always small enough so that the operator has no practical difficulty in seeing the mark when viewing the model, yet the distance is large enough so that the photograph holders can be tilted.

The floating mark assembly consists of several distinct parts. The lenses, with a dot in the center of each, are mounted in holders which can be raised or lowered individually to compensate for variations in flight altitude. The lens holders are supported by slides so that the distance between the dots can be easily changed to correspond with the scale of the photographs and the setting of the pantograph. Incidentally the ease with which the slides can be moved allows a very simple procedure for the relative orientation of the photographs. The framework which carries the floating mark consists of a lower unit, supported by a carriage under the base plate, which can be moved in a horizontal plane without rotation, and an upper unit which can be raised or lowered. This upper unit is supported at each end on a pulley which is screwed up or down on a threaded post. The two pulleys of the instrument shown in Figures 1 and 2 are kept in phase by a leather belt which moves inside the tubes which support the floating mark.

Differences of ground elevation or differences of parallax on the photographs are measured by a vertical motion of the floating mark as indicated on a graduated scale at one end of the frame supporting the floating mark. The stereoscope and photograph holders are stationary, so the vertical motion of the floating mark is directly proportional to the difference in ground elevation. The vertical scale can be computed accurately from the pantograph setting, the horizontal map scale, the principal distance of the photographs, and the viewing distance in the plotter.

[4] An example of the errors caused by an error in focal length was described by G. C. Tewinkel in a bulletin of Syracuse University, Syracuse, New York, in 1940 and cited in PHOTOGRAMMETRIC ENGINEERING, Vol. XI, No. 3, 1945, pp. 263–264.

Photograph holders

The photograph holders of the Mahan Plotter are square plates of brass, each held in position by three screws and a spring on the lower side. A tangent screw at the front of each plate provides a small adjustment of orientation after the photograph is taped or cemented to the holder. The two holders are identical so that both the photograph and holder can be transferred from one side to the other when an adjacent model is set up, a convenient procedure whenever rubber cement is used to hold the photographs flat on the plates.

Pantograph

The pantograph of the Mahan Plotter was designed to allow maps on 1:24,000 or 1:48,000 scale to be plotted from photographs on 1:20,000 or smaller scales. It provides for any enlargement up to 1.78 and any reduction down to 0.36. Since the size of the overlap on the photograph seldom exceeds six inches by nine inches the pantograph could be much smaller than most standard pantographs. A long anchor arm, clamped to the table near the back, was designed so that the map sheet could be placed in the position most convenient for the operator.

Application

The Mahan Plotter was designed primarily for drawing topographic maps. It has been thoroughly tested and refined during the last three years. It has proved to be especially suitable for small scale mapping when used with plane table control and plane table contouring of flat areas in the field. For the best accuracy vertical control is needed for each model. Horizontal control is also needed for each model, but most of it can be obtained from a radial line plot.

The Mahan Plotter as a whole has many features to recommend it. The stereoscope combines a minimum viewing distance with a minimum interference with the motion of the floating mark; the carriage and frame for the floating mark do not interfere with the tilt screws supporting the photograph holders; the pantograph can be set to correspond with any spacing of the floating mark lenses. The operator can remain seated while he views the model, the vertical scale, and the plotted map. Ball bearings have been used in the pantograph and carriage to prevent wear and friction. The various parts have been designed to work together, proportioned to give the instrument a wide range.