INSTRUMENTS

A NEW PHOTOALIDADE

by

R. M. WILSON, Chief, Section of Computing,

United States Geological Survey.

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Photogrammetrists in the United States, in developing the art of topographic mapping, seem to be giving their almost undivided attention at present to the application of stereoscopic methods to the art, using vertical-axis photographs. It is with some hesitation, therefore, that this article is presented, for it has to do with methods that do not employ stereoscopic principles and that make use of oblique photographs only. The Topographical Survey of Canada has adopted for routine practice in photographic mapping in addition to other methods, one that uses oblique photographs, and there is evidence that some interest in similar methods has been aroused in the United States also. So there seems reason to believe that this lesser branch of photogrammetry has enough adherents to make a newly designed photoalidade a subject of interest.

The United States Geological Survey, in making the topographic map of the United States, has for many years used photographs, taken both from ground stations and from the air. Many of the methods involving the use of photographs now employed were developed from the principles and instruments devised by Lt. Col. J.W. Bagley, when he was engaged in surveys in Alaska for the Geological Survey. Colonel Bagley designed a photoalidade to be used with panoramic photographs that is the predecessor of the newer instrument herein described, and the background for the present article is contained to a large extent in a report by him entitled "*The Use of the Panoramic Camera in Topographic Surveying, with notes on the Application of Photogrammetry to Aerial Surveys*", published by the United States Geological Survey in 1917 as *Bulletin* 657.

In 1932, the Geological Survey took under consideration a mapping project in which it was at first proposed to use the methods described in *Bulletin* 657 but, in making the map, to supplement the original Bagley instrument with a new photoalidade that would incorporate certain suggested improvements. The writer prepared the plans for the new instrument, but its construction was postponed for the time being because the project in which it was intended to be used was finally abandoned. This year (1937), however, it was decided that enough use would be made of the new photoalidade to warrant its construction, and the Division of Field Equipment of the Geological Survey, cooperating skilfully and enthusiastically, has embodied the proposed ideas in an instrument of high perfection.

PRINCIPLE AND PURPOSES.

The principle upon which the new photoalidade works is a simple one. A photograph from which it is desired to obtain information is set up in front of the telescope so as to present the recorded view of the ground in its natural relationship to the mechanical axes of the instrument. The illustration shows how easy it is to imagine that the view displayed is a real one, framed in a small open window, and not merely a photograph. Within the field of view presented, all the operations can be conducted that would be possible with an ordinary plane table and telescopic alidade. After orienting the map or work sheet under the instrument, lines may be drawn along the ruling edge to represent directions sighted to objects or features shown in the photograph. Vertical angles also may be measured in the same way that they are measured when the ordinary telescopic alidade is used in the field.

Manipulation of the new photoalidade will seem a surprisingly familiar operation to any one accustomed to the use of a plane table. It is true, however, that there will

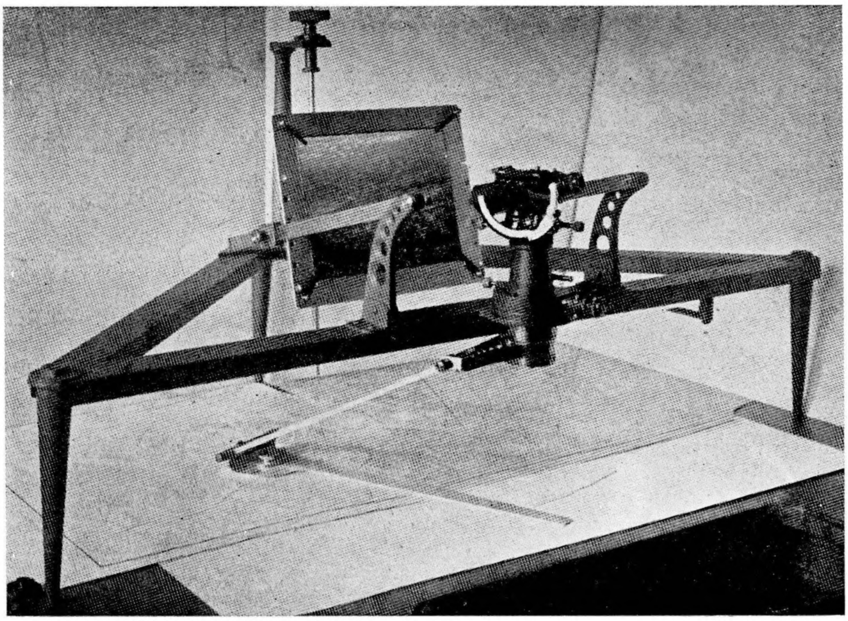

Fig. 1

Photoalidade T_1

be a sense of limitation because of the restricted field of view afforded by the instrument, which presents, perhaps, the most serious difficulty in its use.

The instrument will serve several purposes in mapping. With its aid, topographic features may be located by intersection and their altitude determined, provided oblique photographs of the area to be mapped have been taken from several different points of view. Thus the sketching of contours may be controlled, just as is done by using the intersection method with a plane table. The new photoalidade should be particularly adaptable to reconnaissance mapping because of the extensive areas usually shown in oblique photographs.

In compiling vertical-axis photographs by the radial-line method, or in assembling them into controlled mosaics, the number of ground control stations may not be sufficient or the stations may not be distributed in a way to satisfy the requirements of the work. But, if suitable oblique photographs are available, then, with the photoalidade, additional control points may be interpolated among the existing stations to obtain the number and distribution desired.

Identified points distributed throughout a very long, narrow area may be shown "lined up" by an oblique photograph. The foreshortened view indicates the relative positions of the points with very little error in the direction transverse to the long axis of the area. The methods here described are therefore competent to check any warp or twist in the compilation of a long strip of vertical photographs. For this purpose a few oblique photographs should be taken with the camera pointed approximately along the axis of the strip.

The new photoalidade is designed to use oblique photographs taken with any camera whose lens has a focal length of more than 4 inches and less than 14 inches. This range may be extended by using appropriate enlargements or reductions instead of the simple contact prints. The holder will accommodate prints as wide as 12 inches. If possible, photographs that show the apparent horizon near and about parallel to their upper edges should be selected. Those that do not show the horizon may be used, but they are not so easily set up in the instrument. Some of the photographs taken by the United States Navy on special expeditions to southeastern Alaska in 1926 and 1929 are excellent examples of the kind best suited for use with the photoalidade.

An instrumental adjustment makes it possible to use photographs taken with the principal axis of the lens and camera at any angle of inclination from 10 degrees above to 50 degrees below the horizon. The prints may be rotated about their centers on the holder to bring the true horizon of the picture into a direction parallel to the horizontal axis of the holder.

The instrument is mounted, for convenience, on a triangular frame supported by three 9-inch legs. This brings the sighting telescope up to the level of the eye of the operator, who sits at a table of normal height. The spread of the legs allows ample room on the table for maps or work sheets, which can be conveniently shifted into position because of the free space between table and instrument. The straightedge of the photoalidade is on a double-hinged arm, which can be folded so that the straightedge will be out of the way when not in use or lifted from time to time for inspection of the map beneath it. Thus it is possible to sketch freely on the map without disturbing its position in relation to the instrument. A centering microscope fitted with cross wires is provided, so that the station point on the map can be placed exactly in the vertical axis of the instrument. A clamp with slow-motion screw allows the telescope to be turned and set at any desired angle in relation to the straightedge, so that final orientation can be effected without having to rotate the map on the table.

The first essential to the use of oblique photographs in mapping is that the effective focal length or principal distance of the camera lens be accurately known. There are then six elements relating to the position and pointing of the camera when a given photograph was taken which must be determined before that photograph can be used. Three of these elements are the space coordinates of the camera, usually expressed as latitude, longitude, and altitude, although the horizontal coordinates may refer to a local rectangular system instead of the basic geographic system. The three remaining elements, expressed as angles, relate to the orientation of the camera. They are the inclination of the principal axis of the camera, the direction of the horizontal projection of that axis, and the rotation or twist of the camera upon that axis.

Analytical mathematics furnishes several methods by which to compute the six elements just described, if three or more properly distributed points can be identified in the photograph and if the position and altitude of each of these points are known. But it is possible to obtain almost at once, by graphical methods, the approximate settings on the photoalidade which represent the six elements. Then, by simple trials and readjustments, these preliminary graphical determinations can usually be improved upon until a degree of precision sufficient for practical purposes is attained and the long, complete mathematical computation to determine the elements is avoided.

PROCEDURE IN USING.

If a trial line to represent the true horizon can be indicated upon the photograph, the setting of the photoalidade may proceed as follows: Place the photograph at a distance from the intersection of the principal axes of the instrument that is equal to the effective focal length of the lens of the camera. A graduated scale on the arms of the holder frame is provided for this purpose.

Center the photograph on the holder and rotate it until the horizon line is parallel to the transverse axis of the holder. Then depress the holder until the horizon line of the photograph is at the level of the intersection of the principal axes of the photoalidade. If the vernier of the vertical arc, properly adjusted, reads zero, the cross wires in the telescope should appear to follow the horizon line of the photograph as the alidade is turned about its vertical axis.

After the photoalidade has been properly set in relation to the photograph, draw with it, on a sheet of tracing paper, lines to represent sights taken to the control points as shown on the photograph. Then adjust the tracing paper over a map upon which the control points have been plotted, in order to make the familiar graphical, or tracing-paper, solution of the three-point problem. This done, the point from which the lines on the tracing paper radiate will indicate the horizontal projection of the position of the camera station. Prick through this point and mark it on the map. Then lay aside the tracing paper and place the map under the photoalidade, taking care that the marked camera station falls under the vertical axis of the instrument, and turn the map so that the direction corresponding to that in which the photograph was taken is away from the operator. Next, set the straightedge on a plotted distant control point, and with the clamp and slow-motion screw direct the telescope toward the corresponding point on the photograph. This last procedure insures an accurate coordination of the directions observed with the telescope and the orientation of the map. Unless a readjustment in the settings of instrument and photograph proves necessary, the photoalidade is now ready to draw lines for intersection corresponding to any point that the photograph shows. If the angle of inclination of the camera axis is small, as it will be if the horizon appears in the photograph, errors in the settings just described will have a relatively small effect upon the horizontal angles which determine the position of the camera station.

It is possible to compute the altitude of the camera by reading the vertical angle to one or more control points of known altitude. The horizontal distance to these points from the camera station can be scaled from the map and the difference in altitude computed through the right-angled triangle in the vertical plane. The usual corrections for curvature and refraction should be applied. If the angles read to control points on one side of the photograph result consistently in greater altitudes for the camera station than angles read to points on the other side, the results may be brought more nearly into harmony by rotating the photograph slightly about its center. The computed altitude of the camera may provide a correction to the amount of dip used on plotting the true horizon line above the apparent horizon line. Also, the results from vertical angles to near and distant control points may be compared to see if a correction should be applied to the assumed inclination of the axis of the camera.

These vertical-angle tests will probably indicate that the position and direction of the trial horizon line which was indicated on the photograph should be corrected. After a new line has been indicated, the procedure described for setting the photoalidade should be repeated, in the expectation of obtaining an improved location for the camera station. The instrument is then ready to draw more accurately the lines of direction to new points whose positions are to be determined. A similar use of other photographs of the same area, taken from other camera stations, will provide the intersecting lines on the map that determine the positions desired.