AEREO-TRIANGULATION

Theodore H. Drummond

EDITOR'S NOTE: Mr. Drummond has surely hit upon an ingenious idea for "Aero-Triangulation." Although it has no immediate place in aerial mapping, and would require considerable research to determine its practicability, I feel that it is a unique idea worthy of publication.

The use of the gyroscope controlled mount is an excellent idea, but, to my knowledge, the idea has been in research at various times for the past several years with no satisfactory answer. It is my opinion that through ideas like Mr. Drummond's, and the necessary research connected with such ideas, will come the instruments and techniques for photogrammetry of tomorrow.

GROUND control, of course, is an extremely important and necessary operation for aerial surveys, entailing a great amount of time and work in its execution. Brush or timber adds to the difficulty of this work as does rough and badly broken terrain. Some areas are completely inaccessible and the aerial survey would seem to be the ideal way to map it but without the ground control it would not be very accurate.

Aerial survey is very useful in military operations. Over enemy territory where it would be most valuable, accurate ground control is difficult to obtain.

The plan introduced here uses a tow plane and a glider. Both planes are equipped with aerial cameras on gyroscope controlled mounts. Each plane has three cameras used in the triangulation. One camera in each plane is directed towards the opposite airplane, the second one in each plane is directed obliquely to the ground and in the direction of the opposite plane, the third one in each airplane is directed straight down. The gyroscope keeps the camera mounts horizontal and all cameras pointing in their proper direction at all times. The cameras are equipped with masks which have calibration marks for the angles in both axes. These marks show on the photos taken. The cameras and masks are adjusted to give correct and accurate angle readings from horizontal or vertical. These angles can be determined between planes and objects on the ground, etc. Identical objects are identified on the pictures from both planes, and angles to these measured by the calibration marks showing on the pictures.

The known distance between the planes (length of tow cord) is the base for triangulations. With one side and three angles known, triangles may be solved progressively. Horizontal distances on the ground can be determined. Vertical distances may also be calculated.

Variations in alignment between planes due to wind or other forces causing tilt, yaw, etc. may be determined since the camera mounts are held absolutely horizontal by the gyroscopes. These can be corrected for by solving the small triangles. The triangulations for determining distances and also the correction triangulations are shown on the diagram.

The traverse of the objects along line of flight used for ground control can be determined from angles found from the lateral angle calibrations shown on the photos (Fig. 3). The camera mounts being kept exactly horizontal makes the photos true at all times without tip or tilt. The only variation would be in yaw or misalignment of the two airplanes either in line of flight or vertically. Thus with pictures true, the yaw and horizontal misalignment can be adjusted for by rotating or moving the pictures to proper alignment. The vertical variation can be calculated as mentioned heretofore in the correction triangulations.

The pictures in all cameras must be taken at exactly the same instant. This can be done electrically, with direct connection through the tow cable or by radio.

Objects used on the ground for identification between pictures may be natural objects where it is feasible. For more ease in identification, however, these

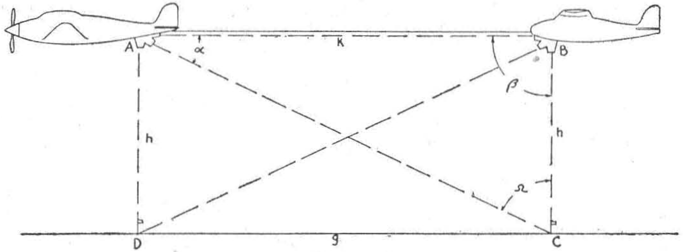
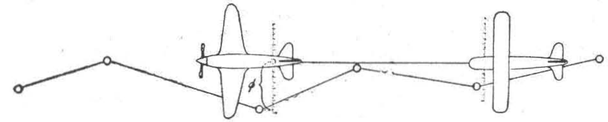


Fig. 1
Ideal condition



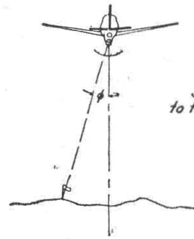


Fig 3
Showing lateral angles used to finally solve true vert. distances.

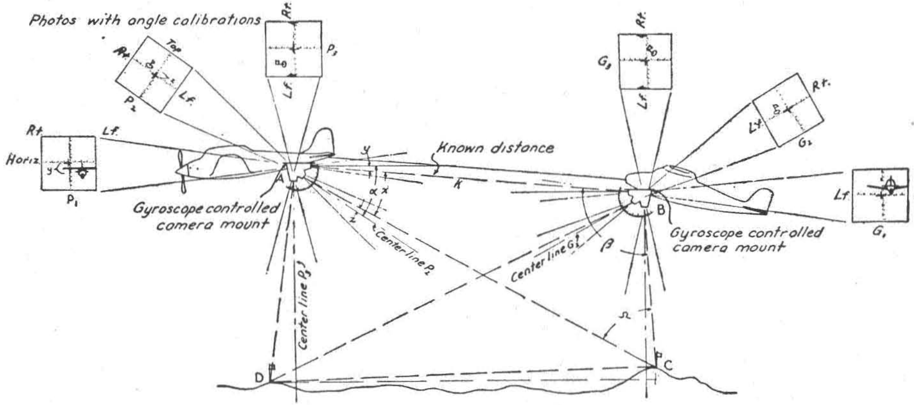


Fig 2
Showing angles for correction and triangulation

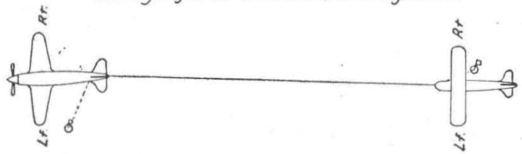


Fig 1 Shows ideal condition in triangulation for finding "g", the horiz. distance on the ground between flags; and "h" the height of camera; "k" is a known distance between cameras. Angles are found from calibrations on photos.

Fig 2 Shows example of misalignment in planes vertically and method of finding angles for correction and triangulation. Gyroscope controlled camera mounts stay level at all times.

Example: Find angle α in Δ A,B,C, Fig 2 corresponding to Δ A,B,C in the ideal condition in Fig. 1

∠x = Fixed ∠ between horiz. and oblique cameras.

∠y = Angle found from photo "P₁" between "horiz." (center line of camera 1) and Back Plane (glider camera 1)

∠z = Angle found from photo "P₂" between center line of oblique camera 2 and back flag.

∠α = ∠x − ∠y − ∠z

∠β may be found in similar manner, then with known distance "k", Δ A,B,C may be calculated

All other Δs may be solved in like manner

Correction Δs may then be solved for obtaining vertical and horizontal distances.

Furthermore: Lateral ∠s as in Fig. 3 finally must be used in solving true vertical distances objects can be dropped from a plane flying low over the area just ahead of the picture taking plane and glider. The markers would be dropped on high points when possible and may be flags weighted on the bottom to make them stand upright on the ground or material which will make a large white spot such as flour bombs but using a more permanent material. They are layed out in parallel lines, lengthwise over the whole area to be surveyed and as nearly as possible in straight lines, close enough together to give adequate control for the strips of pictures flown.

More than one of these lines can be taken in at a time by the picture taking plane and glider. The whole area is covered lengthwise this way, then several flights are made across this area at right angles to these lines to tie the traverses in in this direction.

Since the parallel lines are flown close enough together to give control for the aerial survey strips with overlapping and sidelapping photos, a single camera also mounted with gyroscope carried by either the power plane or the glider takes these pictures at the same time as the control pictures are taken. These pictures are taken along the parallel lines lengthwise of the area and of course not taken when the planes make the transverse tie in flights.

For relative elevations within this area the elevation above sea level need not be known for the beginning control point. For fairly accurate elevations above sea level, the altitude of the plane given by instruments may be recorded. But for accurate elevations above sea level the exact elevation must be known of some point or points in the area. Or if an accurate elevation point is known outside the area it may be tied into the net. Known elevation points at the beginning or end of the flights would be most ideal. If the area borders on the ocean the elevations would be readily obtained.

For military purposes the relative elevations within the area would probably be sufficient where just the knowledge of the terrain was needed for operations. In war zones the elevations above sea level at a starting point might be difficult to obtain unless it was near the ocean.

In ordinary non-military purposes this method can be used to great advantage for inaccessible country. Vertical control can be carried close to the beginning of the survey. It would be of great advantage in any country because of the elimination of the ground surveying.

ANNOUNCEMENT

It is with regret that I announce that, due to his work with the U. S. Geological Survey, Mr. Henry M. Townsend has found it necessary to resign his position as Secretary-Treasurer of our Society. Under the circumstances, the Board of Directors was forced to accept his resignation. They appointed Mr. E. J. Schlatter, Division of Cartography, Soil Conservation Service, U. S. Department of Agriculture, to fill this position.

Mr. Schlatter may be reached by telephone between the hours of 4:30 and 6:30, week days, on WArfield 4200, extension 83; and at his home after those hours on HObart 3246. Mrs. Schlatter will take any message during the day on HObart 3246.