are separate from making the measurements. The data can be handled by hand or put directly on cards or tape for automatic computation. The amount of data recorded varies greatly with test design, and recording and calculating procedures are altered accordingly.

With present techniques the operator measures to the nearest thousandth of an inch. Reproducibility of measurements is on the order of 96 to 98 per cent. This is well within the accuracy requirements that have been established.

Substantial improvements in both efficiency and reliability can be obtained easily with present technology. Essentially an elongated coordinatograph with optical fixtures is all that is needed. Suitably engineered, the readout rate would exceed 90 vehicles per hour with better than 99 per cent reliability.

It is possible to conceive of a monitored automatic electro-optical readout and data conversion system which at the least would more than double the data reduction output and efficiency. In other words it appears possible to develop full utilization of computer techniques. When this occurs continuous stereo strip photography will be the analog source that the traffic engineer will use for creating complete mathematical models of traffic flow and behavior.

SUMMARY

This paper discusses most of the salient points regarding the utilization of continuous stereo strip photography for making traffic measurements involving vehicle speed, volumes, density and spacing. In addition, the usefulness of strip photography for studying many of the factors related to traffic geometry is implied.

Derivation of formulae is not complete, but is sufficient to indicate the nature of the measurements which must be made from the film. Essentially these are image of the air-base and image of vehicle motion.

Secondly, the paper discusses the various factors which might affect the accuracy of various traffic measurements. These are presented individually and are related to the basic accuracy requirements for traffic work. Roll, altitude, and so forth are not deleterious to the traffic measurements, but care is required in the calculation of aircraft ground speed.

Data reduction and processing are considered briefly to illustrate basic feasibility. The fact that stereo-strip photography contains both of the time-displaced images on one film offers tremendous advantages. Ultimately photogrammetrists may be able to handle these data automatically and to provide traffic engineers with the tool he needs to perform mathematical analysis of traffic flow problems.

The end result will be increased safety and more efficient flows with less wear and tear on drivers. This is a goal citizen drivers and traffic engineers as a profession fervently hope is achieved, as the number and density of vehicles using our highway system multiplies each year.

*Aircraft Position Location by Single Photograph Technique**

H. L. CAMERON,
Director, Photogrammetry Division,
Nova Scotia Research Foundation

GENERAL

DURING the summer of 1958 the Royal Canadian Navy carried out evaluation tests on the Decca Navigation system with a view to adapting this instrument to the peculiar needs of the R.C.N. in the Maritime area. The constant position indicator system, using a roller map and stylus, was installed in a number of aircraft including a fixed wing type and a helicopter. The problem of exact

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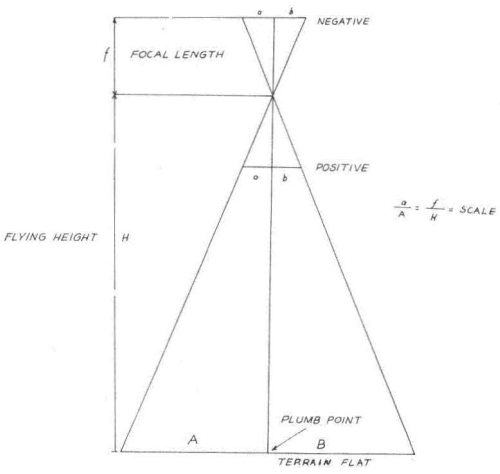

FIG. 1

aircraft position location arose when accuracy tests were proposed to see how closely the navigation system could come to known trig points.

TESTS

Four navigational trig points, all lighthouses, were chosen in the Minas Basin area of Nova Scotia. These were selected on the bases of (1) Accurate geodetic location, (2) Ease of approach from the air, (3) Ease of access on the ground. A helicopter party made accurate ground measurements for the establishment of photo-scales in order to dispense with altimeter and focal-length calibrations.

Location tests consisted of runs over the points by fixed wing aircraft fitted with the Decca instruments with a recording camera. A K20 aerial camera modified for high speed electrical operation was rigged on a fixed mount designed to give vertical pointing when the aircraft was in normal flying attitude. A firing button was arranged to fire the two cameras simultaneously, with the recording camera taking one picture only of the decometers, while the K20 took a burst of three or four frames. It was assumed that the first air shot would record the ground position of the aircraft by its principal point-trig point relationship.

It was obvious from the first few runs that the photos were not vertical and that the plumb point would have to be located in order to check the true aircraft position against the decometer reading position. It was proposed that the standard photogrammetric methods be applied, using stereo-pairs in a first order plotter. This would have entailed ground surveys to locate and obtain elevations on at least four points for each trig point. The negatives would have had to be sent to Ottawa for diapositive plate-making and evaluation in the Wild A8 at the National Research Council. The resultant delays were considered to be prohibitive so other methods were explored. A method of resection from the images of vertical objects was developed to locate the plumb point. After some study and practical tests it was adopted as a solution to the problem. It is briefly described below.

PHOTOGRAMMETRY

In vertical airphotos of perfectly flat ground all objects at ground level are located in their true positions, i.e., the photo is, for all

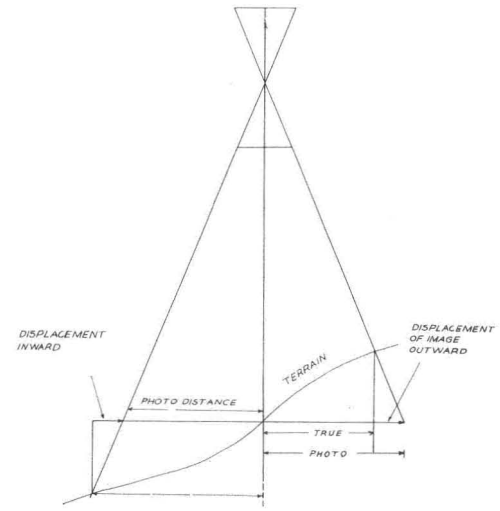

FIG. 2

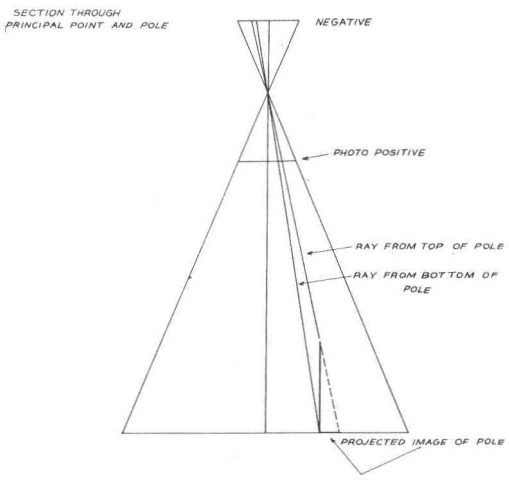

FIG. 3

practical purposes, a map. If objects have height, or the ground surface varies in elevation, objects will be displaced inward or outward, relative to the photo-center or the point directly below the camera lens (the plumb point). Reference to Figures 1 to 4 will illustrate these principles.

As Figures 1 to 3 are any section through the center-point, the principle is usually stated that height displacements are radial from the center-point (in untilted photos), and from the plumb point, in tilted photos.

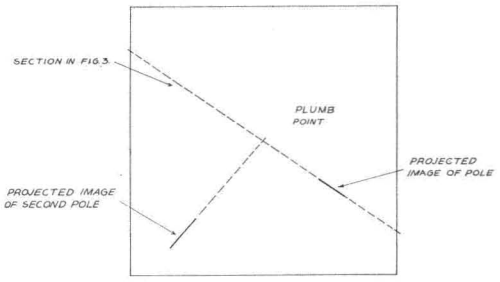

FIG. 4. Enlargement of Photo-Positive.

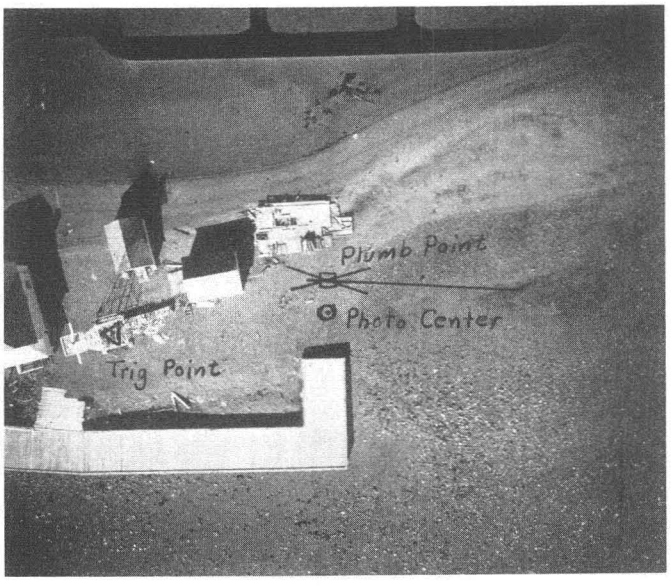

FIG. 5. K20 Airphoto of trig point (lighthouse). Plumb point resected from building corners.

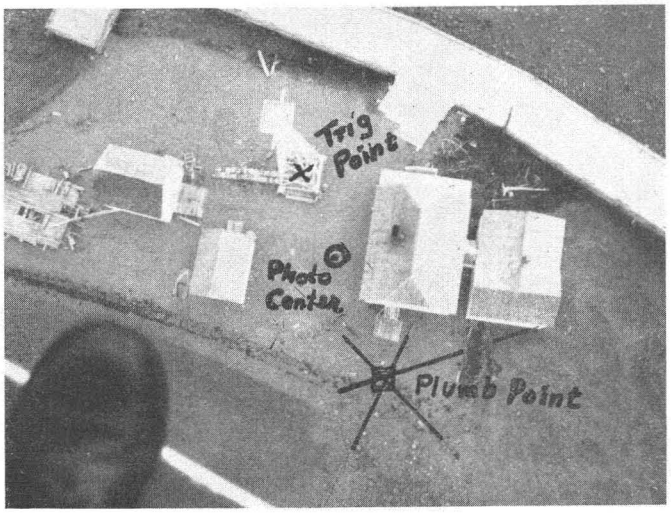

FIG. 6. Polaroid Camera photograph from helicopter. Plumb point resected from building corners.

By reversing this reasoning it follows that the photo-image of a vertical object will be a foreshortened projection of the object (see Figure 3). If the line of this image is projected toward the photo-center it must pass through the plumb point. If two or more upright objects (posts, masts, house corners) are so projected, the intersection of the lines locates the plumb point (see Figure 4). This is shown in Figures 5 and 6.

CONCLUSION

It is concluded that it is possible to locate an aircraft position by taking one vertical or near-vertical photograph at the instant of photographing the Decometers for a Decca position fix. The accuracy is estimated to be within one foot of the true distance. The method used has been named vertical object image resection.

The method could be used for high-altitude high-performance aircraft by using a medium to long focal-length camera and tall objects, such as the masts of a large radio transmitter.

In a city area, such as New York, the corners of buildings could be used.

*Discussion of "One Hundred Years of Photogrammetry"**

J. J. KLAWE in his letter of August 14.
Lecturer in Cartography, Dept. of Geography, High School Yards, University of Edinburgh

"I would like to offer my humble correction to the most interesting article by Mr. Leon T. Eliel entitled "One Hundred Years of Photogrammetry" in your last issue, Vol. XXV, No. 3, June 1959.

"The Surveyor General of Canada, Deville, was the first man to apply the ground photogrammetric survey for actual mapping of the Canadian Rockies but the method which he used was the intersection method and not stereoscopic. The ingenious mechanical device which Deville designed was the forerunner of photo-alidade. If I am correct, this method is still in use in Canada. It is true that Deville did foresee stereoscopic possibilities but the development in this line was only possible after Pulfrich's achievement in this field.

"The pioneering work of Laussedat is rather given credit for his ground survey and not photographic survey."

LEON T. ELIEL in his letter of September 12.

The pertinent portions of the letter are as follows:

"First let me say that I am very flattered that Mr. Klawe went to the trouble to read the article, not to mention the bother of writing about it. I cannot, however, completely agree with his opinion.

"May I ask him to refer to "Photogrammetry, Collected Lectures" edited by O. von Gruber, pages 176 to 178. I particularly refer to the illustration, Fig. 31, on page 177. While, as the article states, Pulfrich and many others who followed Deville, made improvements, the fundamentals of a complete stereoscopic system were incorporated in Deville's conception. It seems that this apparatus was the first to be able to draw contours from a stereoscopic pair of pictures, using the floating mark, and having a drawing pencil articulated therewith.

"While in no way detracting from the important work subsequently done by Pulfrich, I still feel that my paper gave the facts and the credit substantially according to the facts as I know them.

"I again, however, want to thank Mr. Klawe for his interest."

* This paper was read at the 25th Annual Meeting of the Society.