

## A COMMERCIAL LABORATORY FOR THE CALIBRATION OF PHOTOGRAMMETRIC CAMERAS\*

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THIS is to be a three part presentation. I shall give the introductory background. *Mr. David Mann*, whose company undertook to build the rather unusual equipment, will describe the equipment and some of his problems.† My colleague, *Mrs. Clarice Norton*, who is the Director of our Calibration Laboratory, will discuss the process from an optical and instrumentation standpoint.

Back in the early 1930's, cameras used in aerial photography for mapping were a heterogeneous collection of cameras with various degrees of metric accuracy. Many utilized focal-plane shutters.

As the 1930 decade progressed, the demand for photogrammetric maps of a higher order of accuracy increased. It was then that the limitation due to the lack of accuracy of the aerial cameras became apparent.

Attention was first focused upon the shortcoming of the focal-plane shutter when used for mapping photography. Around 1935 or 1936, the use of cameras having focal-plane shutters was discontinued as a result of expressions of opinion at meetings of the American Society of Photogrammetry.

With the most obvious mapping limitation of the aerial camera well on the way toward complete exclusion, and with the demands for map accuracy still increasing, investigation for less obvious camera errors began.

One of the Society's most outstanding contributions for the advancement of photogrammetry started when the Committee on Specifications for Topographic Maps was appointed in 1937. In the Volume IV Number 2 issue of PHOTOGRAMMETRIC ENGINEERING the Committee Chairman, *George D. Whitmore*, recorded the quantitative specifications for topographic maps made by photogrammetric means.

With the target clearly defined by the excellent work of *Mr. Whitmore* and his Committee, the next step was the formation of a Precision Camera Committee under the chairmanship of *Dr. Irvine C. Gardner*. The work of this Committee consisted of working back from the figures of map accuracy, to determine the optical properties of the aerial camera necessary to achieve the desired end result.

The brilliant work of *Dr. Gardner* and members of the Precision Camera Committee is recorded in an article in Volume IV Number 3 PHOTOGRAMMETRIC ENGINEERING (1938). The resulting "Specifications for a Precision Camera," has required no changes through the years, and no significant additions.

The establishment of a respected set of "Precision Camera Specifications" resulted in their inclusion in the bid requirements of all Government mapping agencies. This radical step forcibly created two problems and made it necessary

- a) For American camera manufacturers to design and build cameras specifically for photogrammetric mapping.
- b) For some recognized laboratory to attest the correctness of the various critical adjustments and characteristics.

\* Paper read at Semi-Annual Meeting of the Society, Institute of Geographical Exploration, Cambridge, Mass., September 21 and 22, 1950.

† A few of *Mr. Mann's* illustrations and their descriptions are included in *Mrs. Norton's* paper. Otherwise, *Mr. Mann's* talk is not included in this issue.

The effect of commercial competition, and the desire for progress on the part of manufacturing concerns took care of the first item above. In the second case above, there was only one way out, namely, the use of the facilities of the Division of Optics of the National Bureau of Standards under the direction of Dr. *Gardner*.

The National Bureau of Standards is a research organization whose purpose is to determine and to set up primary standards and techniques of measurement. In accordance with this policy, Dr. *Gardner* determined the necessary standards for precision mapping cameras. He went further and designed and built the necessary equipment for making the required measurements. Thus, there existed around 1938, a laboratory capable of reliably measuring the characteristics of aerial cameras submitted to the Bureau of Standards.

In the first few years following 1938, only a few of the aerial surveying contractors equipped themselves with precision aerial cameras. These cameras, submitted to the Bureau of Standards, provided the Bureau with a means for further perfection of techniques and testing equipment.

Toward the end of World War II, the necessity for precision aerial cameras for mapping was completely established in the United States. The total requirement for precision aerial cameras, caused by the combination of the needs of the Air Forces, Navy, and aerial surveying contractors justified the Fairchild Camera and Instrument Corporation in producing considerable quantities of the first of a series of Cartographic Cameras.

The production of these Cartographic Cameras involved the Bureau of Standards in two ways:

- 1) The lenses had to be measured for resolution and focal length prior to installation in the precision inner cone of the camera.
- 2) After completion of the cone with the lens installed, the Bureau had to check the entire assembly, and in addition had to adjust the fiducial marks.

Here was a real production problem and not research in any sense; simply repetition of testing operations. There was also the attendant nuisance of receiving shipments, storage, accountability, packaging, and shipment. I have seen the time when Dr. *Gardner* and his assistants almost had no floor space at all. They had to climb from packing case to packing case.

An even greater problem for the Bureau lay in the requirements of the Fairchild production and delivery schedules. For most economical production, we had to have tested lenses at certain specific times, to dovetail with our other operations. Then, of course, we were under constant pressure from our customers for final delivery.

Dr. *Gardner* had other work for his department more in line with the policy of the Bureau of Standards. The production testing of Fairchild cameras did not help him achieve his other objectives. Thus, when the first suggestion was made that Fairchild might build a fully complete Camera Calibration Laboratory, Dr. *Gardner* was enthusiastically cooperative.

It was difficult for the Fairchild Camera and Instrument Corporation to make a decision. The number of precision cameras is relatively small; and the cost of equipping and operating a Calibration Laboratory is extremely high. However, after weighing the many factors, the decision was made to establish a Laboratory complete in every respect, and staffed with highly qualified personnel.

In order that the Laboratory might be completely up to date and theoretically correct in all respects, a meeting was arranged late in 1949. To this meeting

invitations were sent to the more interested authorities on optics and precision measurements. Accordingly, we were fortunate to have the assistance of

*Dr. F. E. Washer*, National Bureau of Standards  
*Dr. L. E. Howlett*, National Research Council, Canada  
*Mr. Eldon Sewell*, Corps of Engineers  
*Mr. Paul Pryor*, Air Forces, Wright Field  
*Dr. Constantine Pestrekov*, Bausch and Lomb Optical Company

At this meeting, the general plan for the tests, equipment and procedures was determined. *Dr. L. E. Howlett* agreed to act as consultant on the project. In the course of the past year there have been frequent discussions with *Dr. Gardner*, *Dr. Washer*, and also with the other members of the original group.

Through the coöperation of the above group, there will shortly be in operation in our Jamaica, N.Y. plant, the first commercial Camera Calibration Laboratory in the United States. The equipment used and the techniques to be applied are the outgrowth of the extensive experience of the National Bureau of Standards of Washington, D.C., and of the National Research Council of Canada, both of which organizations coöperated with us generously.

In order to maintain our standards consistent with those established by the Bureau of Standards, it is our intention to submit one calibrated camera at random out of every group of cameras for verification by the Bureau of Standards. In this way we believe we will be able to carry on the high quality of testing established by *Dr. Gardner's* group at the Bureau of Standards.

The purpose of the Fairchild Camera Calibration Laboratory is three-fold:

- 1) To calibrate Fairchild precision cameras in the course of production.
- 2) To re-check and if necessary to re-calibrate Fairchild precision cameras where the demands upon the user require periodic re-certification.
- 3) To check, and if necessary to calibrate non-Fairchild cameras which may be submitted to us.

As soon as we gain some experience in the operation of this new Camera Calibration Laboratory, it is our intention to hold a one-day meeting at our plant for those members of this Society who may be specifically interested in the problem of camera calibration. To insure that we invite all those interested, please signify your specific interest to me or to one of our representatives.

## THE FAIRCHILD PRECISION CAMERA CALIBRATOR\*

*Mrs. Clarice Norton, Director, Calibration Laboratory, Optical-Technical Section, Fairchild Camera and Instrument Corporation*

**I**N PLANNING the equipment necessary for the production testing and calibrating of Photogrammetric Cameras, Fairchild was faced with the choice of either designing two separate test units, one for resolution and the other for distortion, or one all-encompassing test unit.

Since it was felt that a considerable saving of labor could be effected if one test could be made to supply all the necessary data, it was decided to build all the test requirements into a single piece of equipment. Because of the critical distortion requirements, such equipment could only result in a fixture which would be a modification of the very exacting Precision Camera Calibrator

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