*Normal Angle Camera Calibrator**

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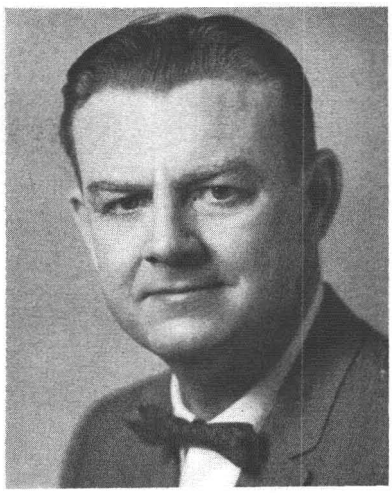
THE rapidly growing field of photographic instrumentation requires the use of many normal and sub-normal-angle cameras, as well as wide angle aerial cameras. The Normal Angle Camera Calibrator was designed and developed to feature the calibration of reconnaissance, tracking, still, and motion picture cameras with angular fields of 40° or less.

The Normal Angle Camera Calibrator, Model I, is a precision instrument that provides a known angular array of targets located at optical infinity. These targets are photographed by the camera under test. The images of the targets are then read and measured to yield the necessary data for the determination of focal-length, location of principal point, distortion, and resolution.‡

A brief introduction to the Wide Angle Camera Calibrator will assist in understanding the evolution of the Normal Angle Camera Calibrator. The development of the Wide Angle Camera Calibrator was started in June, 1955 with an award of a contract by the Bureau of Aeronautics for the delivery of the calibrator to the Naval Photographic Interpretation Center. The U. S. Navy presented many performance specifications; however, the significant requirements were:

a. 90 degree field of view,
b. 2.5 inch clear aperture of collimators,
c. relatively small,
d. relatively inexpensive, and
e. relatively simple procedure for the recording and data reduction phases.

During a period of nearly six years, three models of the Wide Angle Camera Calibrator were developed as the result of a close liaison with military and governmental personnel to incorporate modifications and refinements that were based on the practicalities of operation and test.



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Model III of the Wide Angle Camera Calibrator took firm shape and was exhibited at the March 1961 Annual Meeting of ASP-ACSM. Soon after last year's Annual Meeting, one of our customers contacted us relative to a problem that was experienced when normal or sub-normal angle cameras were calibrated on the Wide-Angle Camera Calibrator. The problem consisted of an insufficient number of targest recorded by the camera under test to conduct a comprehensive data reduction. The relatively small camera field of view in conjunction with targets spaced at angular intervals of $7\frac{1}{2}°$ precluded the recording of sufficient targets.

The Wide Angle Camera Calibrator with side panels removed is shown in Figure 1. The $7\frac{1}{2}°$ interval between collimators is a sufficient interval for wide-angle cameras. The angular interval should be decreased however, when the field of view of the camera being tested is relatively small. For example, only the central target of the Wide Angle

‡ "The 65 targets are nominally positioned to the distortion free position based on the data presented in the NBS Test Report. The precise angular relationship of the target array is determined by a Wild T-2 theodolite as a final calibration procedure."—Excerpted from Mr. McNeil's letter of June 22, 1962.

* Presented at the 28th Annual Meeting of the Society, The Shoreham Hotel, Washington, D. C., March 14–17, 1962. The Abstract for for this paper is on page 346 of the 1962 Yearbook, Vol. XXVIII, No. 2.

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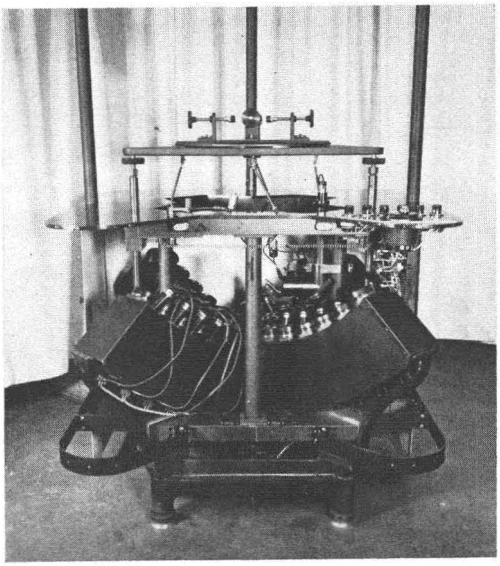

FIG. 1. Wide Angle Camera Calibrator.

Camera Calibrator is recorded by a 35 mm motion picture camera with a 5-inch lens while 29 targets are recorded with the use of the Normal Angle Camera Calibrator.

The Normal Angle Camera Calibrator is illustrated in Figure 2. The basic concept supporting the design of the Normal Angle Camera Calibrator is the utilization of one specially designed collimator lens to cover 65 targest over a field of 40°, in place of installing an individual lens for each of the 65 targets. This optical design approach has two distinct advantages: a) the targets can be spaced at relatively small angular intervals since there is not a space requirement for the installation of a lens and housing for each target, and b) the cost of one larger lens and housing is significantly less than the cost of many smaller lenses and housings. Figure 3 is an optical schematic through one bank of targets.

The collimator lens (Figure 4) was manufactured by C. P. Goerz American Optical Company and was designed by Mr. K. E. Brandt of the same company. The lens, called the Geotar, is a four element air-spaced Gaussian type with a focal-length of 20-inches, a clear aperture of $3\frac{1}{2}$ inches and a full field of 40°. The front and rear crown elements are rare earth glasses and the two inner elements are high index flints. The abstract of the National Bureau of Standards Test Report on the Geotar lens is tabulated in Figure 5.

The targets are placed in the planar focal surface of the lens. There are two banks of targets at 90° to each other as depicted in Figure 6. Each bank of targets covers a full field of 40°. The interval between targets is $2\frac{1}{2}$°. Additional targets are placed at half-angles of 15°, $17\frac{1}{2}$°, and 20° on diagonals of a rectangular format to accommodate amateur cameras with a 24×36 mm format. Two additional banks of targets are placed at 90° to each other. These latter targets are spaced at an interval of 1° and consist of a center-cross only while all other targets contain resolution patterns and a center-cross.

The control panel is shown in Figure 7 There are six rheostats to adjust the illumination intensity of the various zones. Two interchangeable plug-in timers cover an exposure range from 1 second to 10 minutes. The panel contains a display counter to indicate the exposure number. The display counter is synchronized with a similar counter in the focal-plane of the collimator lens. The focal-plane counter is recorded on the calibration negative. A counter defeat switch is mounted

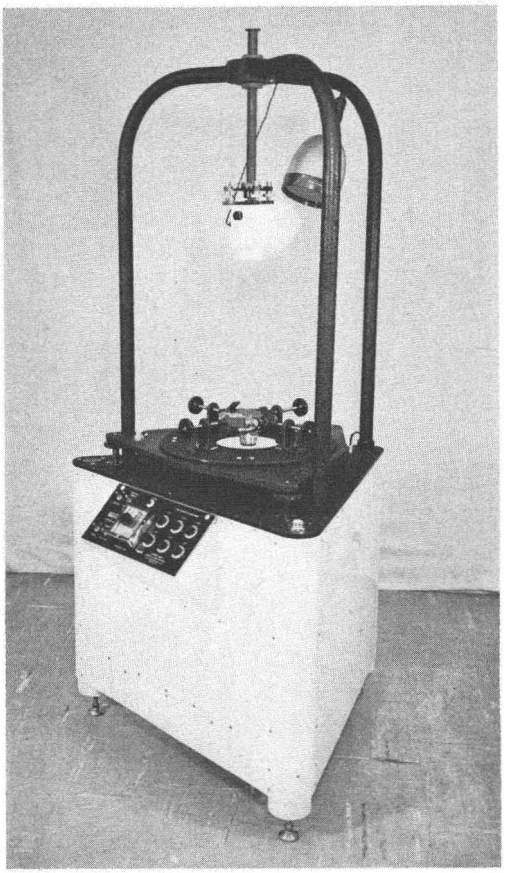

FIG. 2. Normal Angle Camera Calibrator.

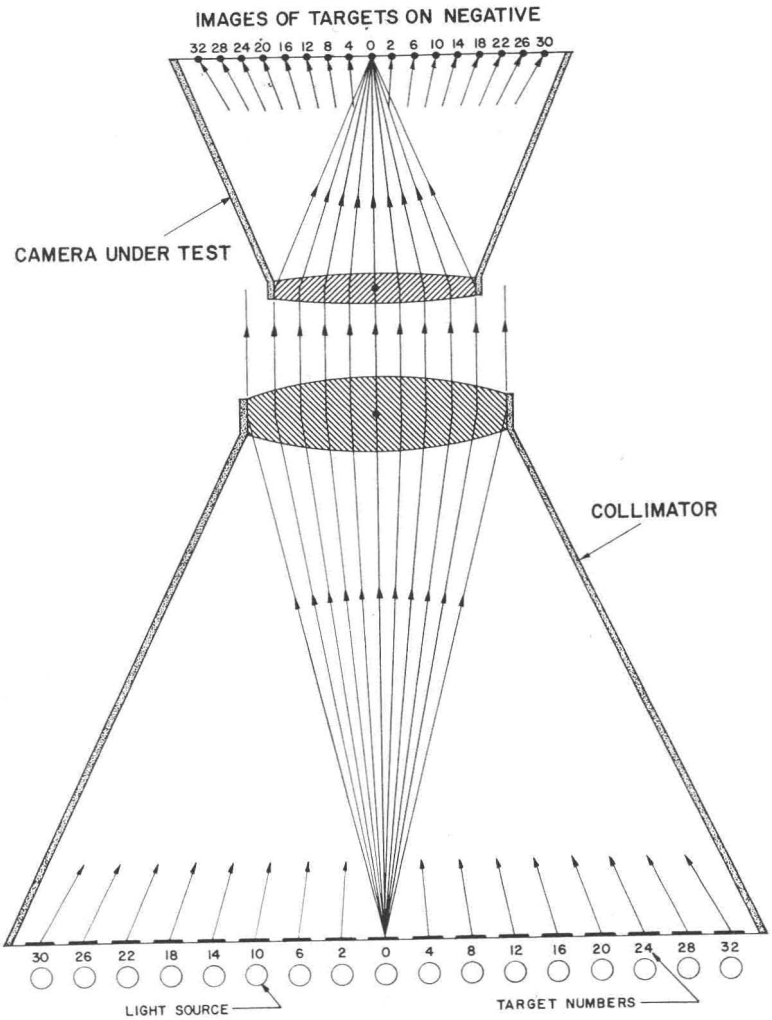

FIG. 3. Optical schematic through one bank of collimators.

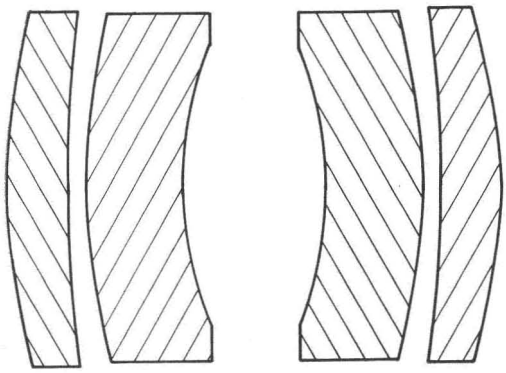

FIG. 4. Goerz Geotar 20-inch focal length, f/5.7.

DISTORTION

5°	10°	15°	20°
-0.01	0.01	0.03	0.14

RESOLVING POWER

	0°	5°	10°	15°	20°
Tangential	46	39	32	23	23
Radial	46	39	32	19	19

Measurements were made photographically at aperture f/6.8 using a K-3 filter, a tungsten source and Eastman Kodak spectroscopic emulsion Type V-F. Development was in D-19 at 68°F for three minutes with continuous agitation.

FIG. 5. Abstract of NBS Test Report.