$2\frac{1}{2}$ miles of the airport, an area covered by obstruction plans. Such phrases as the following are common in the report and evidence the importance of obstruction surveys and approved approach procedures:

"... Pilot departed from standard (approach) procedure—Collide with trees ..."

"Straight-in approach not approved for field was being made ... Struck tree ... "

"Evidence indicates pilot attempted to complete instrument approach by visual reference (not approved) ... Wing struck a 70 foot flagpole ... and fell off and the aircraft dived into a residence, with fire following."

These excerpts are from a cold statistical report. From even such meager detail, however, the imaginative reader can visualize scenes of heartbreaking tragedy. To make even one such report unnecessary is quite a challenge. The author believes that the photogrammetrist with imagination, devoted to that purpose, can play more than small part in meeting that challenge.

# *The Air Photographic Mission*

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COAST and Geodetic Survey air photographic operations cover the United States and its territories, especially Alaska, and provide the specific types of photographs required for efficient mapping in support of nautical and aeronautical charts. These photographs are used for the production of large-scale base maps of the coastline as required for nautical charting, in revising nautical charts, in compiling and revising aeronautical Instrument Approach and Landing Charts, Airport Obstruction Plans, and for location of aids to marine and air navigation. Because of the rather unique requirements, this photography is taken by Bureau personnel with Bureau cameras.

A cooperative agreement has been in effect for a number of years between the U. S. Coast Guard and the Coast and Geodetic Survey whereby a Coast Guard airplane and flight crew are placed at the disposal of the Coast and Geodetic Survey, with the latter providing the photographic equipment, navigator, and photographer.

The singularly different piece of equipment, not used by any other air photographic team, is the nine-lens camera operated by the Coast and Geodetic Survey's Air Photographic Mission. This nine-lens camera was designed by Captain O. S. Reading of the Bureau to meet the specific requirements of coastal mapping.

The principal objectives in the design of the nine-lens camera were to obtain as great a coverage as practicable per photograph (to span water gaps) at the relatively large scales required for detailed mapping of the coast and alongshore features. This camera offers some problems in its airborne operation. First, because of its size (29 inches wide, 27 inches deep and 31 inches high), the camera requires an aircraft with a large compartment to give a photographer access to it from all sides. Secondly, because of its weight (750 pounds with all accessory equipment) the camera places minimums on the pay load and structural strength of the photographic aircraft. The size of the mirror cone and angle of view of the wing lens requires a minimum floor opening through the aircraft 24 inches in diameter. The lens cone must extend clear of the bottom skin of the aircraft when photographing, but must be retracked to prevent mirror damage when not in use. The size and weight of the camera require the installation of a winch to raise and lower it for photography, and to install and remove it from the aircraft.

The first installation of the nine-lens camera was made in a U. S. Army Air Force B-10-B-Martin bomber in 1936. The bomb-bay doors were removed and a temporary plywood floor with a sliding hatch was installed for mounting the camera. The near year the camera was installed in a U. S. Coast Guard BPY flying boat and later in a PBY-5A amphibious flying boat; with this, photography throughout the United States and Alaska was continued

for several years. The airplane carrying the nine-lens camera crashed on Adak Island in the Aleutian Islands, Alaska, in July 1943 with the loss of all but two members of the crew. However, the camera was salvaged and rebuilt by the Fairchild Camera and Instrument Corporation and was recommissioned in September 1945.

In 1949 the Air Photographic Mission began using a Coast Guard PB-1G (B-17) for both nine-lens and single-lens photography. This aircraft has been modified and specially equipped for aerial photography. The nine-lens camera is mounted over the large reinforced opening left where the bottom ball turret was removed. There are two single-lens camera hatches; one was provided originally in the floor of the radio compartment and recently enlarged to allow installation of an Wild Heerbrugg RC-8 with an infragon cone; the other hatch was specially built in the after section for the Wild RC-5. This arrangement permits simultaneous infrared and panchromatic mapping photography. The comparative rendition of shoreline details adds much information for compilation, particularly in extremely shoal waters.

The plastic nose, the Norden bombsight, and the large compartment in the nose section make this aircraft ideal for the precise navigation required of mapping photography. During photographic operations the Coast and Geodetic Survey navigator has actual control of the aircraft through the autopilot and bombsight. The navigator uses a radar altimeter to determine photographic altitude above the terrain and gives corrections to the pilot for the barometric altimeter which is used to maintain flight altitude. This aircraft has good stability, moderate to high ceiling and a reasonable cruising range. It is, at present, the most ideal aircraft for the Bureau's aerial photography requirements except that its reliability and maintenance are becoming a problem to the Coast Guard because of its age and the shortage of replacement parts.

The Air Photographic Mission operates across the United States and in Alaska as an independent field party without organized logistic support. The Coast Guard crew consists of Pilot, Co-pilot, Radioman (technician) and three aircraft mechanics. The three mechanics maintain and make all possible repairs to the aircraft during the photographic season without having the assistance of additional facilities normally available. This arrangement allows for the greatest flexibility of the operation as the maintenance checks can be made wherever the required engine hours are reached in the schedule of photography. This also permits the mission to base its operations at remote areas in Alaska where supporting facilities are not available. The radioman is qualified to maintain all of the electronic communication and navigation equipment in the PB-1G.

The photographic navigator is a commissioned officer of the Coast and Geodetic Survey who has been specially trained for this assignment. Insofar as the Bureau is concerned, he is Chief of Party and is responsible for carrying out assigned photographic projects. The operation of the aircraft is, of course, under the regulations of the Coast Guard and all matters of flight policy are decided by the pilot, who is the Commanding Officer. The photographic operations are generally coordinated and the desired photography accomplished efficiently.

The aerial photographer is a Civil Service employee of the Coast and Geodetic Survey who has been especially trained in the maintenance and operation of aerial cameras and the associated equipment, and in the handling and processing of aerial film. His skill in maintenance of this equipment adds to the independence of operation of the mission without field support. The photographer also develops test exposures from each roll as a check on camera operation and quality of photography.

The photographic navigator is appointed as an Assistant Disbursing Officer by the Coast and Geodetic Survey to add to further mobility of the mission. This permits handling of party expenses independent of any fixed base of operation.

The photographic mission operates in Alaska in the summer where the original mapping of previously unmapped coastline in the Aleutian Islands and western Alaska is still in progress. Mapping photography along the coast of continental United States is usually taken in the spring and fall just prior to departing for Alaska and upon return from Alaska. Past experience of the Air Photographic Mission has shown that best advantage of the few days of photographic weather is most of Alaska can be made by basing operations in or near the area of desired coverage. To be "on-the-spot" in some of the remote areas

requires "setting-up-camp" on an airfield from which the aircraft can operate, but where living facilities are not normally available. Since all personnel on the Air Photographic Mission are volunteers, they tackle the cooperative job of improving their own accommodations with enthusiasm and imagination.

The independence from support by local facilities in working areas becomes impossible on occasions and the mission is deeply indebted to Coast Guard, Air Force, and Civil Aeronautics Administration facilities, both in the United States and Alaska, for their generous assistance.

# *Practical Exposure Determination for Aerial Photography*

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ABSTRACT: *The U. S. Coast and Geodetic Survey has developed a method for varying the exposure and development of the aerial photographic negative to produce a desirable and constant negative density range, regardless of the brightness range of the scene. Beginning with the desired characteristics of the photographic print, a definition of the "perfect aerial negative" is attempted and a practical method for producing this negative is presented. The method does not require special equipment for the determination of correct exposure, nor does it require an uncanny ability for evaluating the brightness range of the scene. The success of the method has been due to the control of all of the other variables through a scientific application of the sensitometric data published by the manufacturer of the negative.*

## INTRODUCTION

SEVERAL years ago it became necessary for the Coast and Geodetic Survey to replace its aerial photographer. He was one of those unusual men who, through many years of experience, had developed a special ability in the evaluation of the illumination level and the brightness range of aerial scenes. Whereas he needed only to look at the scene to determine the correct exposure and development, he found it quite impossible to explain his mental processes to the new photographer. Inquiries of other organizations revealed that each had its own more-or-less empirical methods for exposure determination, and most of them were using a fixed degree of development. It was then decided that the only solution to the problem was a more scientific approach which would minimize the human element.

The manufacture of photographic emulsions has reached a stage of perfection which has changed photography from an art to an engineering science. The photographic engineer can now design a negative to fit almost any desired specification.

The most natural definition of the "perfect negative" is, "that negative which, when printed on normal contrast photographic paper, will most nearly reproduce the scene as it appeared before the camera." Although this definition is excellent for most types of documentary photography, it requires modification in one way for newsprint photography, and in the opposite way for portraiture.

Aerial photography requires still another definition for the "perfect aerial negative." With the exception of photography intended to give special pictorial effects, all aerial photography is made for the purpose of recording as much of the terrain detail as is possible regardless of the atmospheric conditions. The method of exposure and development determination which is described in this paper is designed to produce the *perfect aerial negative*