

spring the lower wooded sections must be photographed for then the trees are still bare and the ground formations can thus be distinguished. In the summer those areas are to be considered which during the hottest days are snow-free, namely the Swiss Alps.

The airplane crew consists of two men, the survey photographer and the survey pilot. The results of the entire photographic activity depend on the co-operation of this crew.

The duties of the pilot are as follows: in charge of all flying, navigation of the plane and supervision of the attendance to the plane at the air base.

The observer is responsible for the entire photographic activity, laying out of flight plans, calculating the exposure times, completing the photographic exposures from the plane and the getting out of the entire material to the time when it is turned over to the Bureau of Photogrammetry.

These, briefly, are the outstanding features in aerial photography.

United States

AMOUNT OF PHOTOGRAPHY ACCOMPLISHED

The map on the next page shows the areas photographed in continental United States to April 1, 1938, and the additional areas for which contracts have been let by the Department of Agriculture to June 1, 1938.

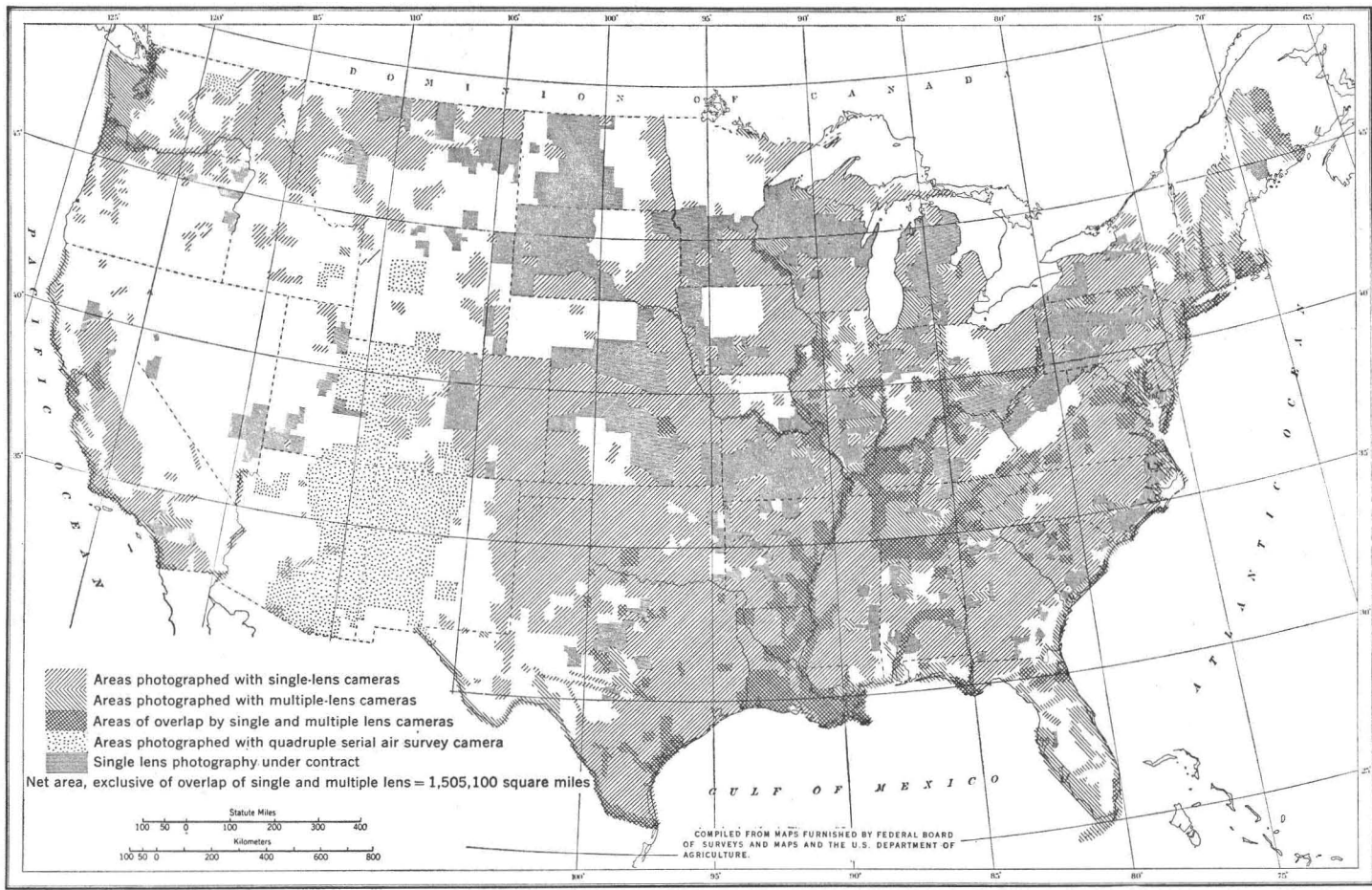
The total net area photographed to April 1, 1938 is 1,505,100 square miles (3,898,200 sq. km.), not including duplication of areas where new photographs have been taken to supersede older photographs.

In addition to this area, 55,000 square miles (142,400 sq. km.) have been photographed in Alaska with the Bagley type (three and four lens) cameras and 3,400 square miles (8,800 sq. km.) have been photographed in Puerto Rico with single lens cameras.

Figures are not available for the areas photographed or contracted for since April 1, 1938, except for the Department of Agriculture. New areas for which contracts for photography have been let by this department up to June 1 are shown on the map and amount to approximately 435,000 square miles (1,126,000 sq. km.). This does not include the contracts of the Department of Agriculture for rephotographing of areas previously photographed but for which the older photographs are not suitable for the needs of the department.

The greater part of this photography has been done for the various agencies of the federal government including the Geological Survey; the Corps of Engineers, U. S. A.; the Coast and Geodetic Survey; the Tennessee Valley Authority; the Brazos River Conservation Authority; and the Soil Conservation Service; the Forest Service, and Agriculture Adjustment Administration of the Department of Agriculture.

The total area photographed and contracted for by the Department of Agriculture in continental United States from 1926 to June 1, 1938 (including the rephotographing of areas for which the original photographs are not suitable for modern use) is 1,582,052 square miles (4,097,000 sq. km.). The total cost for the 1,582,052 square miles (4,097,000 sq. km.) will be \$6,049,724.00. The photographs are used by the Department of Agriculture for planimetric mapping of forest areas, and soil conservation projects, and for the administration of the Crop Control Program of the Agriculture Adjustment Administration.



STATUS OF AERIAL PHOTOGRAPHY IN THE UNITED STATES

June 1, 1938

Of the total amount of photography for the Department of Agriculture, 1,019,361 square miles (2,640,145 sq. km.) or 65% is primarily for the Agriculture Adjustment Administration for the determination of crop areas and not for mapping. However, these photographs are available for the use of other agencies of the federal government.

AIR CAMERAS

Up to the present time, the greater part of the photography in the United States has been done with the five lens, Tandem five lens, and K-3, K-3B, and K-5 single lens cameras.

Until recently, the design of single lens cameras has been directed largely to the production of dependable automatic operation and interchangeability of camera parts as in the K-3B camera. However, during the past two years, considerable study has been devoted to the design of precision single lens cameras with fixed cones and precise construction as regards the lens and the relation of lens, focal plane, and collimation marks. The results of these studies are discussed in the paper by Dr. Irvine Gardner in this report. Several new precision photogrammetric cameras are now under design and construction in the United States.

The new nine lens camera of the U. S. Coast and Geodetic Survey which is discussed in the paper by Lieutenant O. S. Reading is the result of intensive study towards the production of a more precise instrument for accurate air photographic mapping with a minimum of control.

Single Lens Cameras for General Use

1. K-3B Camera, Fairchild Corporation: Designed as a general purpose camera for both oblique and vertical photography, this camera has been used extensively for mapping photography during the last five years. Camera data: negative size 7×9 inches (18×24 cm.), roll film, magazine capacity of 110 exposures, mechanical pressure plate, interchangeable magazines, adapters for cut film or plates, interchangeable lens cones for lenses of 8¼ to 24 inch (21 to 61 cm.) focus, Fairchild between the lens shutter, shutter speeds of 1/35 to 1/150 second, fully automatic or hand operation, weight 44 to 60 lbs. (20 to 27 kg.) depending upon lens used.

2. K-5 Camera, Folmer Graflex Corporation: Negative size 7×9½ inches (18×24 cm.), roll film, flattened by vacuum operated by Venturi tube, magazine capacity of 100 exposures, interchangeable lens cones for lenses of 8¼, 10, 12, and 20 inch (21, 25, 30, and 51 cm.) focus, focal plane shutter, hand operation, separate mounts for vertical and oblique photography, weight with 12 inch (25 cm.) cone and 75 feet (23 m.) of film, 37 pounds (17 kg.), weight with 20 inch (51 cm.) cone and 75 feet (23 m.) of film, 45 pounds (20 kg.).

3. F-4 Camera, Fairchild Corporation: Designed as an all purpose type camera for vertical or oblique photography, for limited mapping work, training purposes, and pictorial photography. Camera data: weight 38 to 53 lbs. (17 to 24 kg.), negative size 7×9 inches (18×24 cm.), roll film, magazine capacity 110 exposures, interchangeable magazines, adapters for cut film or plates, mechanical film flattening, interchangeable lens cones for lenses of 8¼ to 24 inch (21 to 60 cm.) focus, adjustable focus, adjustable iris diaphragm, focal plane shutter, shutter speeds of 1/75, 1/100, 1/150 and 1/225 second, hand operation.

4. F-8 Camera, Fairchild Corporation: Compact, lightweight camera designed for training, reconnaissance, and for general use where a lightweight compact camera is needed. Camera data: weight 18½ lbs. (8½ kg.), negative size

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5×7 inches (13×18 cm.), mechanical pressure plate, roll film, magazine capacity of 40 exposures, lens of 10 inch (25 cm.) focus, equipped with focussing mount for instant adjustment to sharp focus for distances from 8 ft. (2½ m.) to infinity, focal plane shutter for speeds of 1/50 to 1/200 second, hand operation.

5. F-14 Camera, Fairchild Corporation: A compact camera designed for use where insufficient space is available for larger cameras. Camera data: negative size 7×7 inches (18×18 cm.), roll film, mechanical pressure plate, magazine capacity of 100 exposures, interchangeable magazines, lens of 8¼ inch (21 cm.) focus, between the lens shutter, automatic or hand operation.

Single Lens Cameras for Special Purposes

1. K-6A Camera, Fairchild Corporation: Designed especially for high altitude oblique photography. Camera data: negative size 7×9 inches (18×23 cm.), roll film, mechanical pressure plate, magazine capacity of 110 exposures, interchangeable magazines, lens of 20 inch (51 cm.) focus, hand operation, focal plane shutter.

2. F-1 Camera, Fairchild Corporation: A compact camera for oblique photography with 20 inch (51 cm.) focus telephoto lens. Negative size 5×7 inches (13×18 cm.), roll film, mechanical pressure plate, magazine capacity of 50 exposures, interchangeable magazines, interchangeable lens cones for lenses of 7, 10, and 20 inch (18, 25, and 51 cm.) focus, between the lens shutter, hand operation.

3. K-7C Camera, Fairchild Corporation: Designed to operate at low temperatures for high altitude vertical photography. Camera data: negative size 9×18 inches (23×38 cm.), roll film, magazine capacity 45 exposures, interchangeable magazine, lens of 24 inch (60 cm.) focus, between the lens shutter, hand operation.

4. F-11 Camera, Fairchild Corporation: Designed for long range oblique photography. Camera data: negative size 5×7 inches (13×18 cm.), roll film, mechanical pressure plate, magazine capacity of 40 exposures, adapter for cut film or plates, telephoto lens of 40 inch (101 cm.) focus, focal plane shutter, hand operation.

5. Precision Camera, Aero Service Corporation: This camera has been built in response to a demand for precision cameras suitable for use with stereoscopic machines.

The camera cone is integral with the collimation frame and the lens is accurately positioned in the cone by means of a ground washer and pins. The camera is equipped with a between the lens shutter.

The film is held flat in the focal plane by air pressure against a movable pressure plate. Negative size 9×9 inches (22.8×22.8 cm.) with a magazine capacity of 250 exposures. The film rolls are arranged one above the other on the vertical axis of the camera to avoid throwing the camera out of balance when the film is wound from one spool to the other.

Fairchild Night Air Camera

The apparatus consists of a camera with a special lens and shutter. The focal length of the lens is 13½ inches (34 cm.), and the plate size is 8×10 inches (20×25 cm.). Also part of the equipment is a photo-electric cell, a control box which serves to increase the output of the photo-electric cell, and a special aerial flashlight bomb. The method of operation is quite simple; the bomb is released and, after a predetermined interval, it explodes. The photo-electric cell is so adjusted as to operate only at the peak intensity of the flash. The impulse

created by the photo-electric cell is transmitted through the control box to the shutter, causing the exposure to be made. The resulting photographs are of such a quality that only people experienced in the use of aerial photographs can differentiate between photographs taken at night and those taken in the daytime.

New Single Lens Cameras Under Construction

A number of new cameras are under construction in the United States for which descriptions are not available at this time. Two of these cameras which are now under design are mentioned below.

1. Model K-15 Camera (Proposed): The Model K-15 camera will include practically all the interchangeable features of the K-3B camera. A new style magazine will be used which will accommodate longer lengths of film than have been used heretofore. In addition to greater capacity of film, the negative size will be increased from 7×9 inches (17.8×22.8 cm.) to 9×9 inches (22.8×22.8 cm.). Provision will be made for the use of lenses of 6 inch (15.2 cm.) and 8¼ inch (21 cm.) focal length. Other details regarding the design of this camera have not been released by the manufacturer, Fairchild Aerial Camera Corporation.

2. Wide Angle Camera (Fairchild Aerial Camera Corporation): Designed as a wide angle camera for photogrammetric use, it is expected that the first experimental model of this camera will be completed in June, 1938. Details regarding the design of the camera have not been disclosed as yet.

SPECIFICATIONS FOR A PRECISION MAPPING CAMERA¹

Irvine C. Gardner

ABSTRACT: A precision mapping camera² is defined as a camera capable of producing photographs suitable for the making of maps of the highest accuracy that is economically feasible. Specifications for such a map are given. Details of camera construction and camera tolerances consistent with these map specifications are discussed. Two types of optical equipment are considered: the objective having a focal length of 8 inches (20.3 cm.) covering a field 9×9 inches (22.8×22.8 cm.) or 7×9 inches (17.8×22.8 cm.) and the objective that covers an extremely wide angle.

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I. INTRODUCTION

The requirements of the government agencies interested in crop control, soil conservation, large scale irrigation projects and the installation of hydro-

¹ Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

² This paper presents the results of work done for the American Society of Photogrammetry by the Chairman of its Committee on Precision Cameras. The judgments and opinions are those of the writer and have not been considered or passed upon by the Committee.