at the scale of 40 ft to 1 in. The location and plane coordinates of instrument points on the proposed survey baseline are determined, based on the Connecticut State plane coordinate system.

Due to the accelerated highway program in Connecticut, it has been necessary to employ consulting engineers for survey and for design. Many of these are using photogrammetry in varying degrees for topographic map compilation at the scale of 40 ft to 1 in. as follows

1. For interchange areas it is usually more desirable to determine exact ramp locations during the latter stages of design. It is becoming increasingly more common to photograph these areas and photogrammetrically compile topographic maps with contours on a 1-ft interval, thus enabling the designer to measure cross-sections from the maps for any desired location.
2. In urban areas the base map is prepared by photogrammetric methods, supplemented by ground surveys. The cross-sections and/or spot elevations are later measured by ground surveys.
3. The use of aerial photographs, enlarged to the topographic mapping scale of 40 ft to 1 in., is increasing, particularly in cities. These enlargements are used in studying proposed highway locations on developed properties, as a means to refine the proposed baseline and as an aid in property appraisal and acquisition.
4. There have been several instances where the consulting engineers, in order to complete preliminary design, approximate grading quantities, and establish grade lines, have had topographic maps compiled photogrammetrically of highway routes with a 2-ft contour interval. The cross-sections and profiles measured from these maps are later revised in accordance with data obtained by ground surveys.

The Highway Department contemplates greater use of topographic maps compiled at the scale of 40 ft to 1 in. in the future for highway location, design, and preparation of construction plans.

USES OF PHOTOGRAMMETRY BY THE WISCONSIN STATE HIGHWAY COMMISSION

Since early in the 1950's the State Highway Commission of Wisconsin has contracted the services of a number of photogrammetric engineering firms to furnish topographic maps and allied data for the planning, location, and design of highways. By 1961, approximately 2,000 sq mi of aerial photography flying and 600 sq mi of topographic mapping were completed on highway locations within the State.

The small staff within the Design Section of the Commission is engaged principally in the administration of photogrammetric engineering contracts, construction of aerial photographic mosaics, and the training of engineers in appropriate phases of aerial surveys, including photogrammetry and photographic interpretation for highway engineering purposes.

Contract Administration

The services of photogrammetric engineering firms for taking aerial photography and compiling topographic maps have been engaged by negotiation rather than by bid, and excellent results have been attained. Specifications generally follow those prepared by the Photogrammetry for Highways Committee, jointly sponsored by the American Society of Photogrammetry and the American Congress on Surveying and Mapping, as published by the U. S. Bureau of Public Roads, with some variations brought about by local conditions of climate, topography, and land use.

Both fall and spring have been satisfactory for taking aerial photography for compilation of reconnaissance-type topographic maps to a scale of 200 ft to 1 in. with a 5-

ft contour interval. Spring has been consistently better than fall for the small contour interval and large-scale requirements of topographic mapping for the design of highway locations and preparation of detailed construction plans, because more detailed topographic conditions are discernible when grass and other vegetation has lain dormant under snow cover for several months during the winter. In addition, for States of mid-continent and high latitude location, such as Wisconsin, suitable photography may be obtained throughout a longer period of time during the spring. In fact, in the upper reaches of this State, fall flying is possible only for less than one week, and if weather conditions are adverse, it is not possible at all.

Because of the nature of the topography within certain highway project locations, many aerial survey contracts had to be tailored to provide contour interval and map scales that are both usable and feasible for route location and design. Although the topography of Wisconsin can be generally described as moderate, many areas exist where local relief precludes standard renditions of the flying height-contour interval relationship. Along the high bluff area of the Mississippi River in western Wisconsin and in the northeast and north central areas of the State, specifications were adjusted to allow for variable flight heights and contour intervals. Along the Mississippi River, for example, photography was flown at a flight height of about 3,000 ft above mean elevation of the ground. Two-foot contours were compiled over the existing roadway areas and in other areas where the slope did not exceed a 10-ft rise in 50 ft. Where the slope was steeper than a rise of 10 ft in 50 ft, only contours at a 10-ft interval were shown; however, supplemental contours were indicated for a narrow band adjacent to the roadway at a 5-ft interval. This contour variety facilitated design in an area in which it would otherwise have been difficult, if not impossible, to represent and measure configurations of the ground by use of one contour interval only.

Mosaic Construction

The Design Section has constructed a sizable number of individual photographic mosaics in various forms for reports and public hearings. Normally, 12-in. focal length aerial photography at scales of 800 or 1,000 ft to 1 in. is taken in conjunction with 6-in. focal length photography which is taken for mapping purposes. These are the most desirable photography scales for photographic mosaic compilation and use. In addition, use is made of 6-in. focal length photography from the U. S. Geological Survey and 8¼-in. focal length photography from the U. S. Department of Agriculture. The former is preferred, especially in areas of deciduous tree cover. Enlargements of aerial photographic mosaics have been very effective for presentation of route proposals at public hearings and preparation of preliminary engineering reports. Such mosaics, initially prepared for route reconnaissance and allied purposes only, have found their way into a number of other phases of highway engineering, such as planning and demonstrating highway construction progress.

Special Purpose Photography

Gratifying results have been obtained from the use of oblique photography for right-of-way purposes. Property owners are able to visualize the effects of a particular highway location on their property if the road centerline is superimposed in perspective on an aerial oblique photograph. About 75 flight line miles of oblique photography coverage were obtained recently by negotiated contract on the Interstate System. The consultant used a 12-in. focal length K-17 aerial camera, flew at a height of approximately 2,000 ft above ground, and took the photographs with a 30^0 depression angle. Two sets of contact scale prints were furnished. The original film negatives were later used by the section's photographic laboratory for making additional contact scale prints and scale ratio enlargements as needed.

Effective use has been made of a cooperative arrangement between the Highway and Aeronautics Commissions. Aircraft and pilot are utilized on an hourly rental basis, and a photographer, equipped with a press-type camera from the public relations staff, is able to procure oblique photography coverage of specific locations on very short notice. A complete oblique photography record of 50 mi of Interstate highway construc-

tion, from location survey staking to roadway surfacing, was accomplished in cooperation with the U. S. Bureau of Public Roads using this arrangement.

Cross-Sections Measured Photogrammetrically

In 1958, aerial photography was taken over a section of highway approximately 12 mi long for experimentally measuring cross-sections by photogrammetric methods. District survey crews under the guidance of the consultant established all horizontal and vertical control necessary for the project. Cross-sections at every 100-ft station and at breaks in grade and ground slope were measured for about a 350-ft width across centerline and digital information was furnished in punch card form for subsequent input to an electronic data plotter. More work of this nature is planned.

Past experience using consultants for aerial surveys and mapping has led to present plans to continue negotiating engineering contracts for this type of service.

AERIAL SURVEYS AND USES OF PHOTOGRAMMETRY FOR HIGHWAYS

Aerial Surveys Branch, U. S. Bureau of Public Roads
Washington, D. C.

The Aerial Surveys Branch was officially established in 1952. This was not the beginning, however, of the actual use of aerial surveys by the U. S. Bureau of Public Roads. Instead, it was the culmination of more than two decades of use by a few employees of the Bureau of aerial photography for highway engineering purposes. The uses began elementally and were gradually increased in detail, precision, and scope. Creation of the Branch followed directly the successful completion of a comprehensive aerial survey to locate feasible highway routes through a 90,000 sq mi area in the central United States. Previously aerial surveys had been utilized advantageously on numerous projects for route location and design purposes. Among the significant project examples are:

1. George Washington Memorial Parkway, 1928,
2. Pioneer Road for the Alaska Highway in Canada and Alaska, 1942;
3. Inter-American Highway, 1947-48; and
4. Mississippi River Parkway (now Great River Road), 1950-52.

The principal responsibilities of the Branch are to:

1. Promote better design through use of aerial surveys;
2. Develop, improve, and disseminate information on methods, standards and practices;
3. Exercise leadership in writing specifications for aerial surveys;
4. Perform liaison and consultation services;
5. Conduct conferences and schools in aerial surveying for highway engineering purposes; and
6. Serve as a central source of information.

Aerial surveys for highways comprise taking and using aerial photographs, regardless of their type or scale and manner of use, while accomplishing the essential photographic interpretation (including photogrammetry and electronic computer applications) and requisite ground control surveys.

Reconnaissance Surveys

Reconnaissance surveys for determining feasible routes and comparing them to select the best route have been completed and reports have been prepared for highway projects of diversified traffic requirements and various construction standards in re-