On the evening of June 17, Dr. Charles Camsell, Deputy Minister of Mines of the Dominion of Canada, gave an address entitled "A 4,000 Mile Flight Over Northwestern Canada in August 1935". Dr. Camsell was in charge of this exploration and illustrated his trip with motion pictures describing the flight from Prince Rupert Island to the Artic Ocean and return to Edmonton.

The most satisfactory result of the Rochester meetings, from the point of view of members of our Society, was the interest shown in our meeting. Several of our members attended the joint meeting on June 16 of the Section of Physics and the Section of Geology and Geography at which not over 50 were present. At the meeting of the Engineering Section on June 17, only about 15 were present while we had about 85 at our meeting. Reports of any larger section meeting were not available.

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PHOTOGRAMMETRY IN 1936

by

Lieutenant O. S. Reading
U. S. Coast and Geodetic Survey

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Photogrammetry in 1936 resembles the automobile industry in 1910 or the radio in 1920. By this is not meant that hundreds of millions of dollars are soon to be made in its development. Rather that heretofore it has been the work of a few enthusiasts and that at present there are indications that photogrammetry may shortly attain a wide general appreciation of its usefulness with a resulting large expansion. Modern airplanes with their dependable engines, their weight carrying capacity, their increased cruising radius and performance at high altitudes have made aerial photographs practicable anywhere, even over Mount Everest. Modern cameras, lenses, and photographic materials, together with present-day airplanes, have made it practicable to obtain in a few hours an extraordinary detailed, accurate, permanent survey record that, to duplicate by ground methods, would take years of work. The photographic record requires considerable office processing for the construction of a first class map but nevertheless it represents a tremendous step forward in surveying efficiency.

For more than three centuries text books on surveying have been hailing the planetable as the ideal instrument for mapping. On the planetable the map is made in the field with the earth before it as a model; the surveyor may measure the position of as much detail as he finds necessary for his particular purpose. Instead of depending on a notebook, he may check his survey against the earth before him until he is reasonably sure his map satisfactorily represents the ground. The planetable, however, has one inherent and unsurmountable weakness - its limited view from the side of objects which must be mapped as if viewed from above. This limited view means many set ups if all objects mapped are measured. Practical considerations usually render necessary a large amount of sketching from a limited number of set-ups thereby limiting the amount and accuracy of the information mapped. Very accurate, highly detailed maps made exclusively by ground methods are quite expensive often costing a hundred or even several hundred dollars per square mile. The extraordinary development of airplanes and air photo mapping transcends this limitation. Instead of laboriously traversing and retraversing the ground for making thousands upon thousands of measurements in the field, modern aerial photographs, with comparatively little ground work, but with a certain amount of processing in the office give highly detailed, accurate, large scale maps at lower cost than the old, generalized, small scale ones from ground surveys.

The photographs themselves differ from maps in that all objects appear as viewed from the point of exposure rather than from vertically above as on maps. The map maker regards photographs as a record of directions from their exposure stations. The intersection of such directions from at least two overlapping photographs is necessary to determine accurately the map positions of a point unless its altitude

is known from sources other than a single photograph. The map shows objects by conventional symbols which are unmistakable if one refers to its symbol chart; the photograph shows objects by lights and shadows which require interpretation, sometimes difficult if one is not familiar with the country. It is impracticable to show all the infinite detail of a good photograph by hand drawn lines on a map, but the photograph shows a lot of insignificant detail prominently, such as freshly plowed fields or shocks of grain, while significant detail, such as buildings, streams and roads may be partly hidden by trees and difficult of interpretation. When the areas to be shown on a single sheet become large, the necessary reductions in scale reduce the photographic detail until it can no longer be seen clearly.. Clear reproduction of the line maps in large quantities is much more simple and less expensive than that of photographs. It should be borne in mind, however, that the photographs are original records showing everything that sunlight reaches while the maps show only that which the more or less limited sight and intelligence of the map maker perceived inevitably accentuated by his interpretation. Thus the photographs and maps supplement and improve each other. With both available, one can study them in the comfort of an office and readily obtain information that would require weeks of surveying on the ground. The maps will supply true distances, positions, heights, names and conventional interpretation. The photographs help to correct any omissions, generalizations or mistakes of the cartographer. Moreover, if notes are made of the few uncertainties to be settled by a rapid ground inspection, one can be sure that his information about the basic facts of the land is complete and correctly related - a fact not true without map and photographs, even though a thousand men were employed to make notes and write reports.

Photogrammetry in 1936 delivers a variety of products, some of which will always be standard and some only expedients to give limited specialized information as promptly and as inexpensively as possible. First, there is the pair of aerial photographs under a stereoscope. If one has normal sight in both eyes, nothing equals such a combination for first-hand comprehension of the "lay" of the land unless it be an expensive, elaborately constructed relief model. Second, there is the mosaic of photographs pieced together to cover a larger area. Such a composite assists in visualizing and solving some problems for which exact scale and position are not important. Care and skill is necessary to avoid considerable discrepancies and to obtain even color tone but usually mosaics can be made more rapidly and less expensively than line maps.

Then there are several methods by which perspective representation of the photographs can be changed to an orthographic or vertical projection in compiling line maps. One is continually being surprised with the flexibility with which the photographs lend themselves to these different methods, most of which are specialized to meet some particular requirement with the greatest efficiency under limitations of time and equipment. Thus, in the Tennessee Valley, property maps of the reservoir sites were made by measuring the elevations of the property corners and an occasional distance upon the ground. The scale and perspective corrections to the photographs were then computed with specially prepared slide rules and laid off on enlargements which had been printed to a uniform datum. The corrected lines were then traced to form the property map. This process was found to be about three times as fast and one third as expensive as equivalent work with the transit and tape upon the ground.

Most of the planimetric maps (maps without contours) are made in this country by what is called the radial line method. The trace of the ray from the lens to the object to be located is shown on the photograph as a line radiating from its principal point (intersection of the lens axis with the photograph). The intersection of the lines radiating from the centers of two or more photographs of the object gives its map position free from appreciable perspective displacements, provided that the axis of the camera did not deviate more than a degree or so from the vertical as the photographs were taken. Expert photographic pilots and photographers can usually obtain photographs sufficiently good for this method.

More satisfactory are the various machines constructed in Europe for solving mechanically and optically the intersections of rays and for automatically tracing the map. These machines cost from thirty to seventy thousand dollars and, therefore, a large capital outlay is required. In the past two years, the Zeiss Company has developed a Multiplex Projector which costs only about seven thousand dollars delivered in this country. This machine does satisfactory work on contour intervals of ten feet or more. Five such machines are already at work in the United States, three at Wright Field, one in Chattanooga and one in Syracuse. The Fairchild Aerial Survey Corporation has at Los Angeles a Zeiss Stereoplanigraph, one of the largest and most accurate plotting machines. There are three Hugershoff Aerocartographs, an intermediate type of plotting machine, one in Los Angeles, one at Wright Field and one belonging to the Geological Survey. Very recently Lieutenant Talley at Wright Field has devised a much simpler stereoplotting "gadget" which is capable of tracing contours directly from the photographs and is much less expensive than any of the plotting machines. The contours so traced require correction for the scale variation due to different heights but this can be done by several practicable methods. This "gadget", as he calls it, should be very useful where there is not sufficient work to justify one of the more expensive machines, whose product does not require such correction.

No stereoplotting machines whose work do not require later correction are built in the United States at this time, but Mr. O. M. Miller of the American Geographical Society with the collaboration of the Mann Instrument Company is preparing designs for one. Mr. Miller's machine is to use the same principle of viewing a small spot of light as a wandering mark which is attached directly to the tracing point as he uses in his single eyepiece oblique plotter. The small spot of light is viewed with a telescope through a pin hole in a reflecting surface, appearing as a spot of light on the reflected image. By this direct view, all lost motion between the tracing point and the wandering mark is eliminated giving a theoretical advantage over existing plotting machines constructed in Europe. It is hoped that Mr. Miller may construct a machine according to his designs shortly and that it will realize all its theoretical advantages.

As to cameras, the Fairchild Aerial Camera Corporation is the only company actively manufacturing and selling aerial cameras intended for mapping in the United States. They manufacture a large variety of film cameras noted for reliable automatic operation and interchangeability of parts. They built a five-lens camera to specifications of the Army Air Corps which takes a strip four times as wide as a single lens. A tandem five-lens has also been devised. This instrument takes an octagonal field 143 degrees across. Recently they have built a nine-lens camera according to U. S. Coast and Geodetic Survey specifications which it is hoped will improve considerably the efficiency of mapping from the air.

During the past year or two, the Bausch and Lomb Optical Company has made "Aerostigmat" lenses with apertures of F 4.5 and F 6 which compare very favorably with lenses of the same type made in Europe. Recently they have also made a lens which satisfactorily covers a field of 80 degrees at a stop of F 11. During the last few years the Eastman Kodak Company has reduced the shrinkage of its film base for topographic mapping from nearly one percent to about one-tenth of one percent and greatly increased the speed of its fine grained panchromatic emulsions. A new Zeiss single lens camera is reported to have a field of 90 degrees, if the emulsion used has sufficient latitude to record satisfactorily an exposure at the edges one tenth as strong as at the center of its field. Dr. I. C. Gardner of the U. S. Bureau of Standards has recently been granted a patent on a new wide angle lens. This lens is to avoid the extreme range of light intensity and attain an even wider field by introducing negative distortion which is later to be removed by reprojection through a similar lens. All these items indicate that the development of photogrammetry will advance as rapidly in the future as it has in the past.

Toward the end of 1934 the American Society of Photogrammetry was organized in Washington and now has a membership of about 450. Last year Colonel H. H. Blee, our

President for 1936, was chairman of a committee which drew up standard specifications for aerial photographs. These will shortly be adopted and promulgated as standard specifications of the Federal Government. The Society publishes quarterly "News Notes" which describe all important developments in photogrammetry and expects at the end of this year to publish "Transactions", containing the most important papers of the last two years. The American Society is one of the nineteen members of the International Society of Photogrammetry which holds meetings every four years, the next in Rome in 1938. This year the American Society is sponsoring or conducting studies on the amount of ground control needed for standard accuracy in photo mapping, investigating dimensional changes in photographic materials, lens and shutter distortions, and the practicability and advantages of a National Library of Photographs of the whole country.

Although air photo mapping heretofore has been the hobby of a few enthusiasts, it now appears that it may shortly attain a wider appreciation of its usefulness. Over 300,000 square miles will be photographed this year in the United States, the large majority of this amount primarily for soil conservation studies. Table I shows a list of the purchasers and users of the photographs of the State of Connecticut taken by the Fairchild Aerial Surveys in the spring of 1935.

TABLE I

Partial List of Purchasers and Uses
of Aerial Photographs of the State of Connecticut

1. State Planning Board - Entire State.
2. State Highway Department - Entire State.
3. State Agricultural Department - Land Use Maps.
4. State Board of Fisheries and Game - Game Preserve Studies.
5. State Department of Forestry - Enlargements of Forests and General Tree Planting.
6. State National Guard of Camp Locations for training in military use of photographs of locality over which maneuvers were held.
7. Cities and Towns - Enlargements for tax inventories and appraisal.
8. Cities and Towns - Base for property index maps.
9. Utility Companies, Water, Electric and Telephone - For detailed information about areas served by them.
10. Local Engineers - For planning and selling local surveys; determining acreages.
11. Individuals for interest in photographs of their property and its surroundings, especially in connection with improvement of their property and adjustment of boundary disputes.
12. Local Hunt Clubs - Photo maps of their areas.
13. Lawyers - To assist in various legal disputes on property boundaries and damages.
14. U. S. Geological Survey - For revision of quadrangle maps.
15. U. S. Department of Agriculture - In connection with land acquisition.
16. Relief Administration - Studies of watershed areas, stream pollution, rural electrification, industrial census.
17. Schools and Colleges - For courses in physical geography and surveying.

This table indicates something of the value to the whole country of a complete set of photographs made readily available to all at the reasonable costs of a wholesale job.

As a result of tax equalization surveys made with the aid of aerial photographs by the Municipal Service Company of some fourteen towns in Connecticut, the tax rate was decreased an average of 29% and the grand list increased an average of 47%. Such results may well mean the difference between bankruptcy and solvency to many cities in this country.

One has but to look at a few good aerial photographs taken on scales suitable to the area they portray to appreciate that no other means can compare with them for mapping and visualizing facts about the land. Yet such photographs of every foot of the United States could be made readily available in libraries accessible to all for

about ten millions if the job were done wholesale.

Most of the overlooked opportunities, the mistakes and failures of this world, are due to making assumptions and generalizations from half truths and inaccurate information. For nearly three quarters of the United States, the best available maps are but generalized compilations of a heterogeneous lot of poorly coordinated traverses, platts, reconnaissance surveys and sketches. Very few Americans are acquainted with accurate detailed large scale maps of the type made in all the leading countries of Europe. Although most of such maps were made by expensive ground methods and their land of comparable fertility sells for the same price as ours, these countries have found the maps excellent investments. They say they must have such maps to act intelligently and that only a country as rich as the United States could afford the waste of doing without them. The point is that wherever large scale detailed maps are available, hundreds of uses arise which combined repay the cost of such maps many times. But, like first class highways, there are few special projects extensive and important enough by themselves alone to justify their costs. Only the more advanced nations have had the time and intelligence to appreciate and secure for themselves the combined usefulness of adequate maps. We who are working in photogrammetry in 1936 look forward to the day when any man may sit at his desk and visualize, with the aid of accurate detailed large scale maps and aerial photographs, any part of this country in which he may be interested; to the day when he may plan his actions precisely in accordance with the basic facts about the land and move with speed and certainty instead of being compelled to wait for expensive special surveys or muddle through with generalized half truths on many of his maps as at present.

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LENS REQUIREMENTS FOR PHOTOGRAMMETRY

by

Wilbur B. Rayton

Director, Scientific Bureau, Bausch and Lomb Optical Company

(Paper Presented at American Association for Advancement of Science Meeting)

Aerial photography serves the single purpose of obtaining and conveying information. It had its origin and early development during the World War wherein its application was of course purely military. Since the close of the war the possibilities of aerial photography in the field of mapping have been widely recognized and the development of equipment such as cameras, lenses, etc. has been guided by the needs both of the military establishments and the surveyors.

The first aerial photographs were naturally made with such ordinary hand cameras as were available but it immediately became apparent that such equipment was far from satisfactory. In military operations planes were forced to fly higher and higher as the effectiveness of anti-aircraft artillery was improved, and as the altitude of the flight was increased lenses of longer and longer focal length became necessary.

During the war the allied forces found it difficult to obtain lens equipment suitable for their needs, in part because of a lack of optical glass of suitable quality in sufficiently large pieces and in part because of special requirements as to image quality or lens performance that had not, prior to that time, been of sufficient importance to lead to suitable lens designs.

Since the war reasonably satisfactory lenses have become available but with the development of the practice of photogrammetry and a better realization of its possibilities, there has arisen the need for a lens surpassing anything yet achieved by the lens designer.

The main properties of photographic lenses in which we are interested are focal length, relative aperture, angular field of view and image quality. The factors that combine to determine the specifications of a lens are the altitude of the