posed locations of canals, ditches and structures are carefully studied in relation to surrounding culture and tentatively located on the mosaics. Next a field study is made, and if found satisfactory the locations and other pertinent data are inked in. Enlargements are made of small areas of the mosaics and used as the plan on plan and profile sheets.

In mountainous areas, where an effort is made to locate storage possibilities for irrigation water, the topography is carefully studied on the aerial photographs, and likely looking dam and reservoir sites are marked thereon. These are then visited on the ground and preliminary investigations are made to determine their feasibility.

In areas where river stabilization is an important conservation work, aerial photographs are studied to determine the flow characteristics of a stream or river. It is possible to trace the old channel on the photographs, to locate and study bar formations, and it is often possible to find the critical areas in the present stream location. Stream channel stabilization work on a river must be related to the sections upstream and downstream from the critical areas, and nothing offers a better way to study these than aerial photographs. A quick general picture of these conditions is readily revealed which can then be checked on the ground with detailed surveys where necessary.

In areas where faulting is the serious consideration for structural installations, engineering geologists will use the aerial photographs to locate the faults and their projections. The geologist will also be able to locate alluvial fans that may possibly be used for water spreading areas or for well locations.

OTHER USES

The Soil Conservation Service also uses aerial photography for geological studies, forestry, range management, wildlife, and other activities which perhaps can be described at a later date.

ACKNOWLEDGEMENTS

The cooperation of all those who contributed material for this article is acknowledged and deeply appreciated by the author.

USE OF AERIAL PHOTOGRAPHS IN CONNECTION WITH FARM PROGRAMS ADMINISTERED BY THE PRODUCTION AND MARKETING ADMINISTRATION, U.S.D.A.

Ralph H. Moyer, Chief, Aerial Photographic and Engineering Service

THE Production and Marketing Administration of the U. S. Department of Agriculture has recorded on aerial negatives the most extensive panorama of the surface of the United States that has been achieved to date by any public or private agency. Approximately seventy per cent of the total area of this country, including ninety per cent of the agricultural land, has been photographed from the air, for the P.M.A. A considerable area has been rephotographed, and there are now in P.M.A. files aerial negatives for over 3,000,000 square miles.

Aerial photography was secured by the P.M.A. as the most accurate and economical method of determining the extent of the farmers' participation in

the Agricultural Conservation Program and other programs of the P.M.A. These programs, especially the quota and allotment programs, require accurate acreages of fields the farmer had diverted from one crop to another and from soil depleting to soil conserving uses. Each field where these changes have been made must be measured to check their land use changes.

Soon after the Agricultural Adjustment Act was passed in 1933, county and community committees were set up to administer the provisions of the programs covered by that Act, at the county and community level. Programs were set which called for the diversion of acreages devoted to wheat, corn, cotton and tobacco to other uses. This made it necessary that accurate measurements be made to determine the acreage in all fields on which these crops were grown. In order to obtain the first measurements required by the Act, the committeemen employed neighboring farmers to do the vast job of mapping the majority of the farms of the nation. Practically all methods of measurement were used, many of which were of necessity crude and not always accurate. There was one thing common to all of these methods—they were expensive. In some cases, the acreage of the fields on a farm was determined by surveying parties which was probably the most accurate and definitely the most expensive of all the methods used. In other cases, community committeemen measured the fields with chain or steel tapes. Another method was to tie a rag on a bicycle wheel and walk the wheel around each field to be measured, counting the revolutions each time the rag showed on top. The records from these field measurements were taken to the county office where they were computed and acreage determined. In many cases, the equipment in the county office was not of the best and inexperienced help was used.

The final checking of the acreage requirements of the various programs then, as now, was the responsibility of the county committeeman. The community committeemen were elected by the farmers from their communities, and the county committeemen were elected by the farmers from their counties. They were chosen for their qualifications as farmers and good citizens of the community to administer the farm programs at the grass roots. These farmers in most cases were not surveyors or trained engineers of any sort. The results secured in determining accurate field acreages in the first year of the program varied greatly in accuracy, and the costs were very high.

As early as 1934, county offices in charge of farm programs saw the need for speedy, accurate measurements of fields. During that year, at least one county office made arrangements with a contractor for aerial photographic coverage. In 1935, a number of counties in several states were photographed from the air for farm program purposes, and reports on the feasibility of measuring acreages from aerial photographs caused a larger number of counties and states to resort to this method during 1936.

At this time and for several years following, a number of people were dubious about the accuracy of the measurements. Queer things were happening. Fields which had contained twenty acres for ten or fifteen years were found to be nineteen or twenty-one or even twenty-two acre fields. Roads which were supposed to run due north and south, or east and west, were found to be slightly off course. Where a farmer had paid for one hundred and sixty acres, he found he had only one hundred and fifty-seven acres, while the one hundred and sixty acre farm across the road contained one hundred and sixty-three acres. Penalties for overplanting and, in some cases, a desire to prove the aerial photograph wrong, prompted the hiring of surveyors to check the acreages determined from aerial photographs. The fact that photographic coverage was later obtained for

practically all of the agricultural land in the country testifies to the feasibility and accuracy of measuring acreages from aerial photographs.

What had been, to a large degree, an experiment up to 1936 blossomed into a full grown program in 1937. Changes were made in the specifications in order to secure a more usable product. State offices of the Agricultural Adjustment Administration hired engineers and prepared for the inspection and acceptance of photographic materials. Offices were established in the Regional offices of the AAA for the purpose of securing more uniformity, preparing invitations to bid, corresponding with and in general giving assistance to contractors, the State AAA offices, and the two laboratories located in Salt Lake City, Utah and Washington, D. C.

Aerial photographic coverage had been secured for practically all of the agricultural land in the country prior to the start of World War II. Some of the counties photographed during the early days of the program had been rephotographed. Counties had been furnished new sets of ratioed enlargements to replace those worn by use. Many farmers had been furnished photographs of their farms for more careful planning of farm operations. Contractors were experienced and were delivering a much improved product. A uniform set of specifications had been approved for use by the Department of Agriculture. Personnel in the various AAA offices and laboratories were experienced, experience of the type which gave invaluable assistance to the military during World War II.

At the start of the war there were several contracts to be completed. No new contracts were let during the war. The nature of the farm programs did not require accurate acreage measurements, and the military needed huge quantities of photographic materials. The aerial negatives secured by the AAA were used by the military in the training of its men and in selecting camp and plant sites. The two AAA laboratories were busily engaged in preparing mosaics and other types of photographic reproductions for military use. Aerial and photoindex negatives covering military installations had to be classified, and proper measures taken in the county and State AAA offices to safeguard reproductions from such negatives.

The end of the war brought the need for control over the production of certain commodities, and the interest in aerial photography as the means for securing acreage measurements was revived. Many changes had been made in farm land as a result of the war. Considerable new land was brought into production. Existing photographs were from four to ten years old. The program of rephotographing was underway.

Today the need for accurate acreage measurements covers such crops as tobacco, peanuts, potatoes, cotton, and wheat. Rice, corn, sugar beets, cane, and other crops may be in the picture soon. The demand for new photographs is great and is handled on a priority basis. State Committees of the Production and Marketing Administration, having all of the functions formerly assigned the AAA, determine the order in which counties are to be rephotographed. The lists of counties are worked into a proposed invitation to bid and submitted for approval. A check is made on the photography held or being secured by any other Government Agency to determine whether such photography could be used, thereby eliminating the need for reflying. After a proposed invitation to bid has been approved, it is duplicated and sent to the various contractors on the bidders' list on file in the Division of Purchase, Sales, and Traffic, the Chief of which is the contracting officer. The bids received are opened at a set time and date and the awards determined. The successful bidders are furnished with maps on which to plot flight lines. Usually an item area is composed of an area in the south and an area in the north, and is of a size estimated to give the contractor year around work.

The specifications call for photography at a scale of 1:20,000, plus or minus five per cent, with a lens having a focal length of not less than eight inches. The lens and camera must have been tested by the U. S. Bureau of Standards to determine whether the specifications for a precision camera have been met. Endlap in line of flight, and sidelap between flight strips, should average approximately sixty per cent and thirty per cent, respectively. Flight lines are about two miles apart and the height of the plane is approximately 14,000 feet. The crew, which consists of a pilot and photographer, wear oxygen masks in order that their movements will not be slowed down. Photographs are taken only on clear, bright days and during the period when the sun's altitude is at least $3\frac{1}{2}$ hours above the horizon.

The contractor is required to deliver the aerial negatives, photo-index negatives, one set of double-weight, water-resisting, contact prints, one set of single-weight contact prints, three sets of photo-index sheets, and a line index for each county subproject. The photo-index is a photograph of an assembly of contact prints, trimmed to the image edge and carefully laid to match corresponding images. The scale of the photo-index is one inch to the mile unless an entire county can be shown on one $20'' \times 24''$ sheet at a scale of not less than five-eighths to the mile.

All photographic materials are delivered to the P.M.A. Eastern and Western Laboratories, depending on the location of the county subproject area. After inspection, the contractor is notified of acceptance, or of any reflights or changes to be made in the materials delivered. Payment is made on a county subproject basis.

Enlargements are made and furnished to county offices at a scale of 660 feet to the inch. The contact print scale is approximately 1700 feet to the inch. Enlargement ratios are determined by the two laboratories by slotted template or, if available control measurements are insufficient, by cross ratioing to double-weight, water-resisting contact prints resulting from previous flyings, on which ground control measurements have been recorded. After the enlargements are prepared, they are carefully checked for scale and forwarded to the State PMA Office for delivery to the county office. The ultimate use of aerial photographs by the Production and Marketing Administration is for the purpose of improving the individual farms of the nation, making a sound evaluation of needed soil conserving practices for these farms, obtaining accurate acreages of fields diverted from crops under allotments or quotas, and obtaining definite soil conservation uses for such diverted acres. This program is administered by State, county and community committeemen. The ratioed enlargements from the laboratories go to the State Committees and from them to the individual counties. The county and community committeemen then use these photographs to check land uses and crop acreage, in accordance with the requirements of various programs administered by P.M.A. On the ratioed enlargements at a scale of 1 inch equals 660 feet, the areas of the individual farms and the permanent boundaries of fields in each farm are delineated in the county office.

These photographs are then used as intimate maps of the county and community as well as intimate maps of the individual farm. The areas of individual fields are secured in the county office by the use of planimeters, and sometimes in the case of rectangular fields by scaling. The scale of 1 inch equals 660 feet (8 inches to 1 mile) was determined as a convenient scale to use as this scale converts readily into rods, the measurement most commonly used in determining land areas, and 1 square inch equals 10 acres. Where parts of one photograph cover areas at a materially higher elevation than other parts of the photograph, there are sizeable differences in scale. In such cases, the photograph is frequently zoned and conversion factors set up for each area. By applying the proper cor-

rection factor for each zone, the measurements of areas with considerable differences in elevation are given approximately the same degree of accuracy as those for level ground.

Ordinarily only every other photograph in line of flight is enlarged since, with a 65% endlap, there is an endlap between photographs of approximately 15%. In the county office the area which should be used to planimeter fields is determined for each photograph and indicated by lines dividing the overlapping areas of adjoining photographs. The photograph which is needed for any individual farm is determined by consulting the photo index. These photo indexes are made up on a county basis to a scale of approximately either 1 inch to the mile or 2 inches to the mile. In areas which are sectionized, the township and section lines are often placed on the photo index to aid in determining the photograph needed to cover any particular area. Section lines are also often indicated on the individual photographs as an aid to locating any parcel of land according to its legal description. The records for each farm in the county office also refer to the number of the individual photograph or photographs on which such a farm appears so that if it is necessary to consult the photograph it can readily be removed from the files.

Only a few of the uses made of aerial photographs in connection with P.M.A. farm programs have been covered. Many of the other uses are of such a non-technical nature, concerned with the planning of programs, their local administration and assisting farmers in planning the efficient utilization of the natural resources of their farms, it appeared they would not be of sufficient general interest to merit inclusion.

PRACTICAL APPLICATION OF PHOTOGRAMMETRY IN LAND CLASSIFICATION AS USED BY THE BUREAU OF LAND MANAGEMENT*

Douglas E. Henriques, Field Examiner, Colorado-Utah Region, Bureau of Land Management, Salt Lake City, Utah

I AM deeply appreciative of the invitation extended to me to speak on the practical application of photogrammetry in land classification, as used by the Bureau of Land Management. I feel that I am somewhat of an interloper in this group because I am only a tyro amongst this large number of professional photogrammetrists. Also, my agency is not equipped to do original work in the field of photogrammetry as such, but merely adapts the work of others in this field, to fit the peculiar needs of the Bureau of Land Management.

The Bureau of Land Management was established July 16, 1946, by the consolidation of the former General Land Office and the former Grazing Service under the President's Reorganization Plan No. 3 of 1946. The new Bureau is charged with the management, leasing, and disposal of the public lands and the resources therein; the execution of all laws relating to the surveying, prospecting, locating, appropriating, entering, reconveying, and patenting of all public lands within the public domain, the national forests, and other reservations; the administration of mining and mineral leasing on lands under the public domain and under the jurisdiction of the Department of Agriculture; and supervision of

* A talk given at Regional Meeting, Rocky Mountain Section, Denver, Colo., Oct. 4, 1949.