# PART I—1949 RESEARCH PROJECTS

## ARMY MAP SERVICE*

DURING the past year, activity in photogrammetric research at AMS has been directed principally to experiments with the stereoplanigraph and with high altitude vertical photography.

At present, the Photogrammetric Division is making a close examination of stereoplanigraph methods and equipment to determine the effectiveness of the stereoplanigraph as a medium for the extension of vertical and horizontal control. Trials are also being made for the expansion of the uses of this instrument in bridging control in conjunction with multiplex compilation.

Development of techniques for utilization of high altitude vertical photography for the compilation of medium scale maps (1:250,000) is in progress.

Tests are also underway to determine the feasibility of using two sets of photography, taken at different altitudes, in photogrammetric map compilation. Requirements for photography, in so far as vertical measurements or contour compilation are concerned, are much more stringent than requirements for photography for horizontal bridging operations. In other words, the contour interval desired determines the flight altitude of the photography to be used for compilation. On the other hand, the amount of ground surveys required to adequately control the photographs horizontally, decreases with increase of flight altitude. Accordingly, research is based on the premise that photography for horizontal bridging operations may be taken at high altitude, and that photography for compilation may be taken at lower altitude. The combination of the two different sets of photography, if found practicable, will effect considerable economy in field survey operations for horizontal control.

Full value of this research program to photogrammetric engineering cannot be ascertained until a thorough study and evaluation of all results are made upon completion of current tests. It is hoped that the resultant findings will widen the application and extend the possible uses of photogrammetric techniques.

## BAUSCH & LOMB OPTICAL CO.

The following is a brief summary of the progress in photogrammetric research of interest to Bausch and Lomb for the preceding year:

Based on a survey of the effects on stereoscopic models for mapping, particularly on those photogrammetric instruments where "bridge" control is used, research in the "Effects on Map Production by Distortion in Photogrammetric Systems" was reported in the March 1949 issue of PHOTOGRAMMETRIC ENGINEERING.

Based on this research, a second parallel research was conducted to control the uncompensated distortions in the manufacture and mounting of lenses used in Photogrammetric Systems. In the Multiplex System including the Metrogon lens, the reduction of each type of uncompensated distortion introduced by manufacture or by lens design has been reduced to amounts comparable to distortion introduced by lack of camera platen flatness of 0.0005″. The compensated distortion in film was reported in the September 1949 issue of PHOTOGRAMMETRIC ENGINEERING. Included in this article, but a separate research and development project, is the elimination of the residual radial distortion in the Multiplex System to a measured zero. The method originated and selected was the use of a compensating diapositive plate whose surface is shaped. Low cost methods of manufacturing these diapositives in quantities are progressing satisfactorily, and operating tests are being run.

Newly developed features of the Auto-Focus Rectifier, a group of which are now being manufactured at Bausch and Lomb, include those changes recommended by the Engineer Research and Development Laboratories, based on their test and operation of the equipment since February 1948.

Newly developed features incorporated in the Multiplex System for improved map accuracy control are: new uniform light system, internal principal-point control, slow-motion scaling control, simplified, diapositive-holder, elimination of need for cooling unit, a new double frame without center support and a new Multiplex printer for 12-inch Metrogon photography.

## EASTMAN KODAK CO.

Of probable interest to the members of the American Society of Photogrammetry is the availability of a new color film for use in aerial photography. This film is Ektachrome Aero Film, Low Contrast.

* No objection to publication on grounds of military security—Office of Public Information, National Military Establishment.

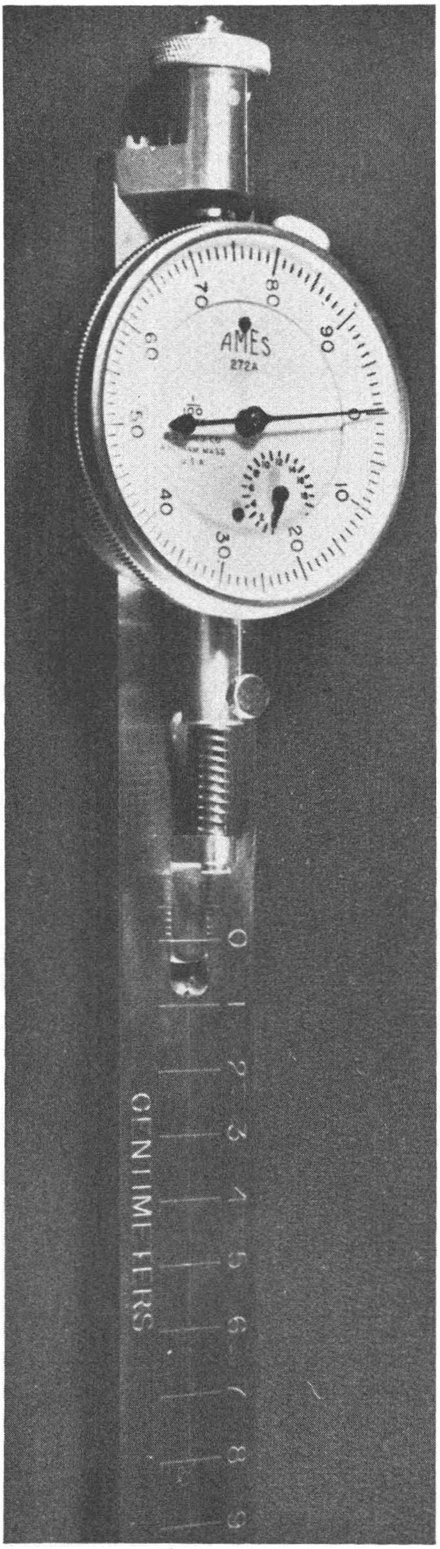


FIG. 1. Dial Gage Meter Bar.

Ektachrome Aero Film, Low Contrast is a reversal color film of the subtractive type, yielding positive transparencies in color when processed as recommended. It is spooled in the same way as black and white aero film, and it can be exposed and processed in the same types of equipment. Special chemicals are required for processing the film, and these chemicals are supplied in kit form with $\frac{1}{3}$, 1, and $3\frac{1}{3}$ gal. sizes available.

Ektachrome Aero Film, Low Contrast is designed for use at low altitudes (approximately 1,000 feet or lower) with bright sunlight on a clear day, or illumination equal to noon sunlight plus sky light. It is obvious, of course, that this film was designed to fill the requirement for low altitude color photography where the high contrast of the Kodacolor Aero Reversal Film is too high for best results. Experience with this new film is rather limited, but the estimated exposure index and recommended meter settings are: Index 12, Weston Meter, 9; G. E. Meter, 15.

## THE KALART COMPANY, INC.

The Kalart "Camera of Tomorrow" represents a new concept in press-type cameras. Range finder, focuspot, view finder, and speed flash equipment are built directly into the camera. There are no outside wires, cables, or protrusions to get in the way

## REED RESEARCH, INC.

The standard of length, so fundamental in cartography, is still the meter and its decimal subdivisions. Unfortunately, however, the physical problem of accurately laying off length on maps has lagged far behind the developed mathematical theories. Cartographers, using trammels or a pair of dividers, have had to estimate their millimeter settings to the nearest one/one tenth for the coordinates of the map plots. Mr. L. M. Samuels of the United States Navy Hydrographic Office conceived a meter bar capable of accuracy to two/one thousandths of a millimeter, using a dial gage in combination with a meter bar. (Figure 1) The good estimating eye or the experienced feel of the practitioner is now aided by a proven scientific instrument.

Developed basically for maps and charts up to fifty (50) inches, the bar is actually graduated for 125 centimeters. Its principle may be adapted to any suitable scale or length required for specified operation. The problem of length stability is met by using $\frac{1}{4}'' \times 1''$ invar stock, ground for true surface and graduated in centimeters from 0 to 125. A V-cut centerline is engraved on the reading surface longitudinally. The centimeter lines are engraved transversely and individually numbered. Centered between 0 and 1, and extending forward to the 0 graduation, a 0.25 inch wide $\times$ 0.13 inch deep and 1.69 inches long slot is machined in the bar to slip-fit the slide.

The slide, 0.75 inch long, is rigidly fixed to the rack spindle of the dial gage. The surfaces of the bar and the slide are in the same horizontal plane to obviate possible error by vertical displacement when setting the trammels or dividers.

The dial gage, manufactured by the B. C. Ames Co. as Model 272M, is graduated into 0.01 mm and its range is 19 mm. The rack spindle is fixed to the slide fitted in the bar slot. Its other end is coupled by a stud screw to the knurled adjusting nut for setting zero on the dial gage. This assembly of gage, slide, screw, and nut is rigidly attached to the invar bar. The only translatory motion is made by the rack spindle and slide. When the slide is replaced, the gage is simply zeroed for the replacement by resetting of the dial face.

A desirable feature of this design allows replacement of the slide, when scuffed or worn by continuous use of the instrument. The slide is the item always used in this type of instrument so its wear is greatest. The conventional meter bar is completely discarded when its vernier end is scuffed and worn by the pin pricks of the dividers or trammels. In this instrument, the slide alone is replaced very inexpensively, while the life of the expensive graduated bar is extended indefinitely.

Errors in settings of trammels or dividers are minimized by the open and easy-to-read face of the dial gage. Setting the desired length by screw motion is an operation familiar to all persons. The resultant lessening of operator fatigue by large, easily read numerals is obvious. Speed in selection of length is realized with this instrument. In all, a more efficient meter bar has been developed for use in cartography and allied fields. Its use should result in a large saving of time in map preparation.

A new and proven mechanical ruling machine, originally developed by the U. S. Coast and Geodetic Survey, was installed in the U. S. Navy Hydrographic Office in January 1949. (Figure 2) This precision machine is manufactured to the following specifications:

1. Rules lines straight and parallel within .03 millimeter throughout total length of line.
2. Rules lines at right angles within 6 seconds.
3. Rules lines of any curvature up to a maximum offset of 65 millimeters in 1,000 millimeters.

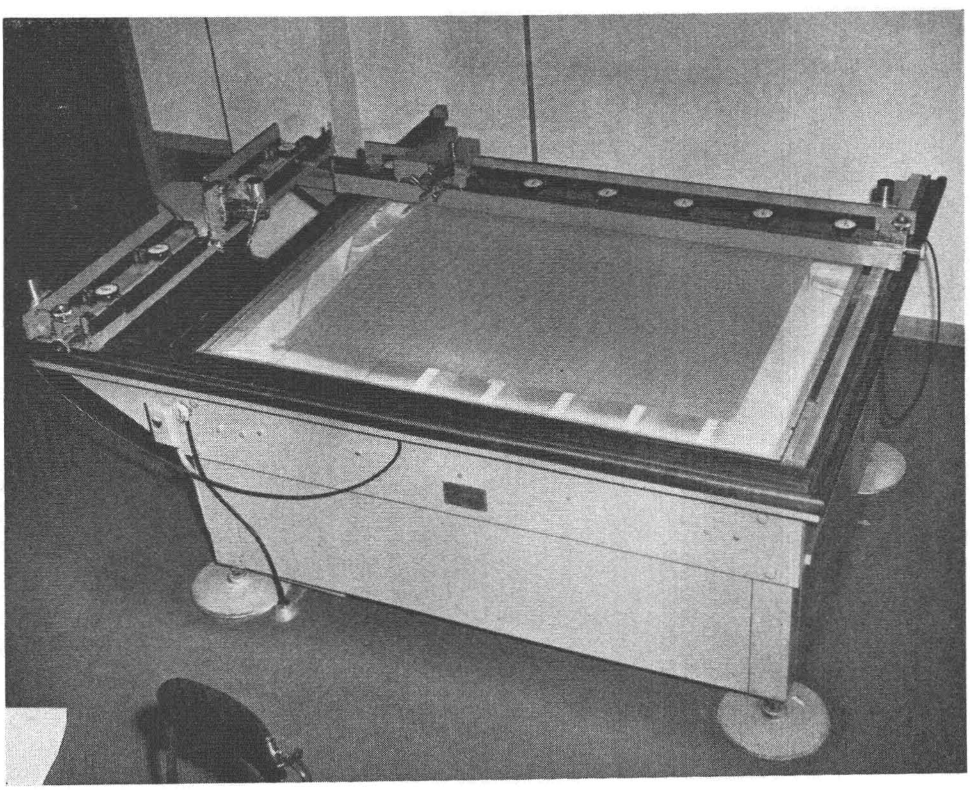

FIG. 2. Mechanical Ruling Machine.

4. Plots points anywhere within an area of 1,140 millimeters by 1,650 millimeters with an accuracy within .03 millimeters.
5. Locates points on charts and maps with an accuracy within .03 millimeter.
6. Rules lines and plots or locates points on any medium up to ½-inch thick.
7. Engraves lines on cooper plates with diamond points or other graver to an accuracy within .03 millimeter.

## DEPARTMENT OF THE NAVY

The Bureau of Aeronautics has only one photogrammetric project which is of an unclassified nature and concerning which information can be published on an unrestricted basis. This project involves the development of a prototype of an improved ratio template slot-cutter, and is being conducted by the Aeronautical Photographic Experimental Laboratory at the Naval Air Material Center, Philadelphia 12, Pennsylvania. The configuration of this cutter (Figure 3) will be based on a Zeiss designed instrument, and it will have the following features:

a. An optical method of positioning the punch relative to a picture point.
b. Means for automatic and manual operation.
c. A ratio range from ½ diameter reduction to 2½ diameter enlargement.
d. Slot cutting to be done on template material rather than the photograph.
e. Accommodation of a 9″×9″ photograph.

It is anticipated that the project will be completed by late 1949.

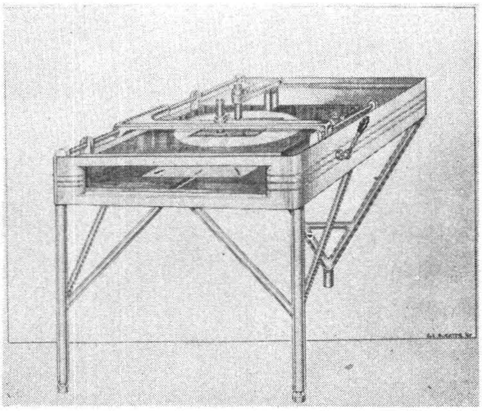

FIG. 3. Ratio Template Slot Cutter.

## U. S. COAST AND GEODETIC SURVEY

The main direction of research during the past year has been the measurement and compensation for errors in the aerial photographs. A nearly level carefully surveyed test area with targeted stations near Toledo, Ohio, has been photographed with various cameras under regular service conditions.

An efficient procedure for compensation of the errors when printing the nine-lens photographs is being developed. Single-lens photographs were checked, but no intensive studies of their errors have been made as yet.

The test area also has been photographed with an F-51 camera having a glass grid in its focal plane, in cooperation with the Naval Photographic Interpretation Center. The first measurements made by the P. I. C. indicated unsymmetrical distortions in the air negative as high as 0.11 mm. The photographs gave satisfactory geometrical relations when corrections to compensate for the distortion, indicated by the grid lines, were applied. The P. I. C. is continuing this investigation with additional photographs and varied processing.

Some data are accumulating on the efficiency of various types of stereo plotting equipment, but not sufficient for reporting as yet.

## U. S. GEOLOGICAL SURVEY

Among the major photogrammetric problems now under investigation by the Geological Survey, are the following:

1. Development of new types of stereoscopic plotters. The specific objectives of the current development projects in this field are:
   a) Greatly increased net area coverage in a single stereoscopic model for a given flight height.
   b) A new method of double projection using, among other new features, larger diapositives than are employed in the Multiplex at present, and an improved light source.
2. Improvements in existing types of mapping instruments, particularly the wide-angle Kelsh plotter.
3. Development, in cooperation with the armed forces, of an aerial camera lens of high resolution, with distortion reduced to a negligible amount.
4. Development of a new type of diapositive printer in which, among other features, distortion compensation is accomplished by the use of an aspheric correction plate in conjunction with

a projection lens of high resolution and precision, resulting in superior qualities in the finished diapositive.

5. Application of new techniques for determining the position of exposure stations, including the use of:
   a) Horizon photography.
   b) Statoscopes.
   c) Shoran.
6. Revision of specifications for aerial photography with the following aims:
   a) Procurement of photographs of better quality with respect to contrast and definition.
   b) Reduction of errors due to:
      1. Radial and tangential distortions in camera lenses.
      2. The lack of film flatness at the instant of exposure.
      3. Movement of the image on the film during exposure.
   c) Adoption of a uniform method of testing aerial cameras, so as to afford a reliable measure of camera accuracy and performance.
   d) Design of photographic projects so as to give the most efficient photographic coverage of the area, fully considering the various factors involved.
   e) Adoption of a more equitable method of payment for accepted photography.
7. Improvement in diapositive plates for various types of instruments, with respect to thickness, flatness, and emulsion characteristics.
8. Development of a coordinate plotter, with changeable gears for operation at various scales, which permits the rapid plotting of rectangular coordinates on large manuscript sheets.
9. Development of a slotted template-cutter adapted from original plans of the U. S. Army Engineer Board.
10. Exploration of the application of the precise photo-theodolite in special projects involving terrestrial photogrammetry.
11. Study of foreign photogrammetric equipment to determine possible application in the mapping program of the Geological Survey.

## U. S. NATIONAL BUREAU OF STANDARDS

Calibration of precision airplane-mapping cameras is greatly facilitated by a new device developed by Dr. F. E. Washer and F. A. Case of the optical instruments laboratory at the National Bureau of Standards. Designed specifically for this purpose, the calibrator overcomes several deficiencies of the instrument that has previously been used; for example, it requires but one negative, whereas the older method requires four. It is also much more compact and incorporates a number of other unusual design features.

As the science of photogrammetry, with its exacting requirements for aerial camera lenses, has advanced within the past few decades, Bureau scientists have been constantly improving the methods for measuring the characteristics of these lenses, including their focal lengths, distortion, and resolving power. According to present specifications, prepared jointly by the American Society of Photogrammetry and the National Bureau of Standards, a precision mapping camera must be provided with a lens that complies with a number of very stringent requirements. Furthermore, it must incorporate such features as a fixed focal plane; rigid connection of lens, focal plane, and camera cone into a single unit; and collimation index markers so located that lines joining opposite pairs of markers intersect at an angle of $90° \pm 1$ minute with the intersection marking the principal point within $\pm 0.03$ mm.

At first these measurements were made visually by means of a visual optical bench. Later, a new precision camera was constructed for conducting the tests under conditions more nearly approximating the conditions of use. Equivalent focal length, distortion, and resolving power are determined from measurements made on a negative produced by the lens under test. This instrument has also been adapted to the calibration of the lens-cone combination of the improved type of precision mapping cameras. The method, however, possesses several serious deficiencies: (1) As suggested previously, four negatives are required, a time-consuming operation, (2) different sizes and shapes of the various makes of cameras cause difficulties in mounting them properly for test, and (3) the entire field cannot be covered with a single photograph. The new calibrator was therefore designed to remedy these difficulties.

A collimator bank, which consists of 25 collimators arranged in the form of a cross, is the heart of the instrument. It is mounted beneath a table and centered below a large circular opening in the table top. The central collimator points vertically upward, and the remaining collimators are spaced at 7.5° intervals along the four arms of the cross from 0° to 45°. Departure from the 5° interval used in the lens-testing camera is necessitated by space limitations. The collimators are mounted in a special casting whose inner and outer envelopes are hemispheres. Accordingly the collimator axes that are normal to the hemispherical surfaces point toward the center of curva-

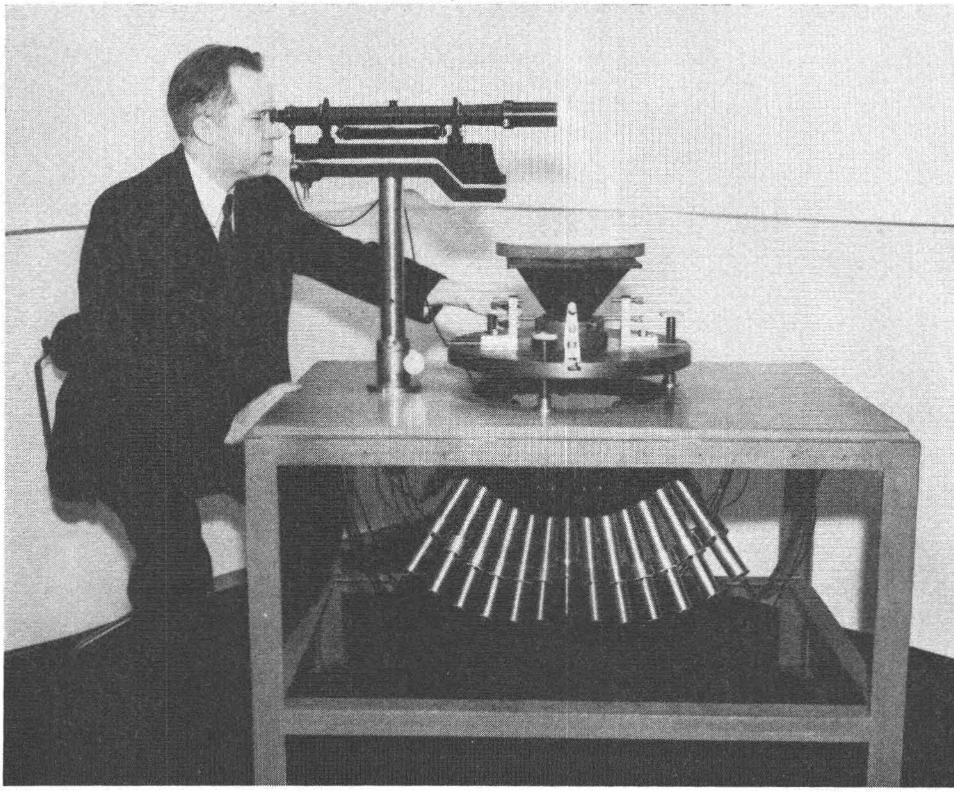

FIG. 4. The new calibrator developed by the National Bureau of Standards for precision cameras consists essentially of the collimator bank, a camera holder, and an automatic collimating telescope whose axis is bent 90° by a prism in front of the objective. The camera is mounted on its holder to point vertically downward through the central opening and thus permit the light from the 25 collimators to reach the camera lens. Images of the targets are shown every $7\frac{1}{2}°$ along each diagonal of the finished negative, with collimation markers registered on the sides.

ture. Accuracy of pointing depends to a large extent upon the accuracy of counter-bored holes and flanges by which the collimators are mounted. However, small deviations can be corrected by small movements of the targets mounted in the focal planes of the collimator objectives. These adjustments are made with capstan screws, so arranged as to afford complete translational freedom of the reticle. After adjustments, clamping by appropriate screws guards against any subsequent movement.

The collimators are of the fixed-focus type with the tubes cut to the proper length so that each reticle lies in the focal plane of the corresponding objective. To guard the collimators against disturbance, the lamp housings are independently mounted on the arms of the cross. For simplicity, the lamp house completely surrounds the target end of the collimator, but does not touch it at any point. A 6-volt frosted flashlight bulb serves to illuminate the reticle. Provision is made for the insertion of a filter and a glass diffusing screen between the lamp and the target.

The camera is pointed vertically downward, mounted on a camera holder that consists of a tripod placed over the opening in the table. The central opening permits the light from the 25 collimators to reach the camera lens. The focal plane of the camera can be adjusted to normality with the axis of the central collimator, with the aid of adjusting screws on the tripod and an autocollimating telescope whose axis is bent 90° by a prism mounted in front of the objective. This arrangement for mounting the camera offers several advantages: (1) Regardless of the type and various irregular protuberances, most aerial cameras can be readily mounted and supported with the lens directed downward; (2) the camera is held in position by gravity, with lateral movement prevented by the movable stops; (3) the glass plate used for autocollimating can be a heavy optical plane parallel, held in place on the focal plane of the camera by gravity; and (4) the photographic plate can be similarly laid on the focal plane, and a heavy weight serves to hold it in place while tending to flatten it during the photographic exposure.

The finished negative shows the images of the targets every 7.5° from the center to the corner along each diagonal. The collimation markers are registered on the sides of the negative, so that there is little likelihood of the target images being spoiled by the light that registers the markers.

The registering of images at known angular separation from the axis out to 45° increases by a factor of 10 the accuracy of determining the shift of the principal point resulting from prism effect. In addition, it should be possible to measure the so-called tangential distortion, which is somewhat of a problem at present. Resolution charts are included as a part of the targets, so that some information on the definition from the center to the corners of the negative can be obtained during the calibration. The small diameter of the collimated beams precludes the possibility of testing the definition at aperture greater than $f/8$ for a 6-inch lens. However, examination of the imagery will definitely show if there are any marked differences in the definition along the two diagonals.

A new resolution chart has been prepared for this instrument. The line spacings in the targets vary in steps equal to the fourth root of 2 and will permit evaluation of the resolving power over the range from 4 to 130 lines per millimeter for a 6-inch lens. Circle targets are included so that comparison between line and circle targets can be studied.

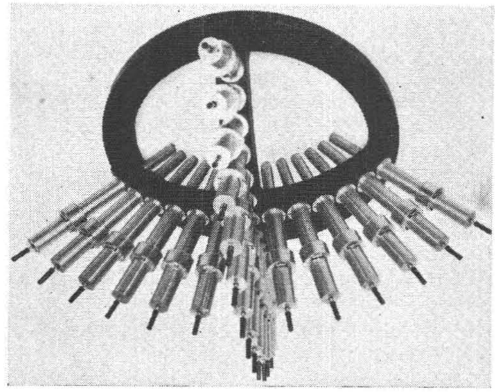

FIG. 5. Heart of the National Bureau of Standards' new instrument for calibrating precision mapping cameras is the bank of 25 collimators arranged in the form of a cross. The central collimator points vertically, with the remaining 24 spaced at 7.5° intervals. They are mounted in a special casting whose inner and outer envelopes are hemispheres.

It must be emphasized that this instrument is primarily intended as a pointing instrument in the sense that it provides 25 beams of parallel light from known directions. The information derived from it will therefore be mainly of a directional nature, and will include data on the uniformity or lack of uniformity in the distortion characteristics of the lens-cone combination. It will permit more rapid and more accurate location of the principal point, together with a determination of the equivalent focal length of the lens as mounted in the camera. It will provide quantitative information on the magnitude of the prism effect and the effect of tangential distortion. Moreover, it will provide all this information on a single negative, so avoiding possible changes that result from small movements occurring between successive exposures. It will provide a more stable support for the camera during test, and also greater versatility in the types of camera that can be tested.

## U. S. NAVAL ORDNANCE TEST STATION, INYOKERN, CALIFORNIA

The Naval Ordnance Test Station has done little work in the field of photogrammetry. However, this Station is interested in the subject, as it applies to the study of dimensional stability of topographic base aerial roll film used for the recording of ballistic data. Since records made on this film are carefully measured to obtain quantitative performance data, increased knowledge of the errors introduced into the calculations by film stretch, shrink, warp, etc., is highly desirable.

The present Smith-Fairchild tank method of developing such records is considered unsatisfactory. Therefore, a continuous machine capable of processing roll film up to 12″ in width has been designed, and is now under construction for this Command. Upon installation of this machine, about 1 October of this year, it is hoped that a series of experiments can be inaugurated to obtain additional knowledge of the amounts of changes induced to film dimensions by varying conditions of processing.

The articles of J. M. Calhoun on this subject, published in the June 1947 issue of PHOTOGRAMMETRIC ENGINEERING, have been valuable in outlining the problems of the field.

## U. S. NAVAL PHOTOGRAPHIC INTERPRETATION CENTER

The following list includes some of the unclassified reports which have been distributed by the P.I.C. Photogrammetry Department, during the past year:

*Title*

Wet Process of Laying Mosaics
Evaluation of Ryker Model PL-3 Stereoscopic
Preliminary Report on the Determination of Water Surface Profiles
Application of Zenithal Star Exposures to Field Camera Calibration
Stellar Camera Calibration Field Guide
Image Point Movement on Oblique Photography
Application of the Porro Principle to Field Camera Calibration
Porro Camera Calibration—Field Guide—Annex I
Guide to Report Writing
Focal Length Determination by Vanishing Point Method
Explicit Three-Point Resection in Space
Explicit Four-Point Resection in Space
Stellar Identification Charts
Proposed Computer for Use in the Sonne Method of Depth Determination
Quality of the Single Aerial Photograph—Wild RC-7 Camera—
Tilt by Scale Variation
Operational Procedure for Use of the Mann Comparator

## U. S. NAVY HYDROGRAPHIC OFFICE

Training personnel to operate high precision stereoscopic plotting instruments is a long, time consuming and costly process. As no standard methods have been available for determining visual adaptation, the selection and testing of applicants or trainees in this specialized branch of engineering are considered important responsibilities of a photogrammetric supervisor. Many weeks or months have been spent in training before discovering that the trainee does not have sufficient stereoscopic ability.

In an effort to find a solution to this problem, Mr. M. H. Salzman, Photogrammetry Section of the U. S. Navy Hydrographic Office, suggested that certain visual tests, similar in character to those used by the armed services in the last war, could be applied in the screening of applicants. In this manner, those who did not qualify could be rejected at the start.

In view of his special qualifications and interest in this matter, Mr. Salzman was assigned to investigate the studies and findings of the Applied Psychology Panel of the National Defense Research Council, to ascertain whether the establishment of a screening test, which would enable the selection of the most adaptable personnel, would be feasible. In this manner, the Hydrographic Office would be assured of obtaining personnel who could become efficient operators and, at the same time, afford economies in training.

It was determined that such a screening test was entirely feasible, and a recommendation was made that the assistance of the Armed Forces—NRC Vision Committee be obtained. At the request of the Hydrographer, made through the Office of Naval Research, the Sub-Committee on Visual Standards of the Armed forces—NRC Vision Committee began work with the Photogrammetry Section towards establishing a profile of visual criteria for the screening test.

A research testing program was arranged by Dr. Henry Imus, Head of the Psychophysiology Branch in ONR. This research testing program, coordinated by Mr. Salzman, provided the raw data, from 25 experienced operators from the U. S. Navy Hydrographic Office, Army Map Service, Forest Service, and Geological Survey, upon which the Visual Standards Sub-Committee was able to base recommendations for a visual profile.

From the results of this cooperative research project, a detailed report is currently being prepared for possible publication in an early issue of PHOTOGRAMMETRIC ENGINEERING.

## UNIVERSITY COLLEGE, UNIVERSITY OF LONDON

The Chair of Surveying and Photogrammetry was founded in October 1946 at the College, and is linked with the Civil Engineering Department. During this period, equipment of the photogrammetric laboratory has proceeded at the same time as the building up of courses in particular to students of Civil Engineering and Geography. Professional Courses for Land Surveyors have been inaugurated.

The Photogrammetric Laboratory contains a variety of equipment including Wild Phototheodolite, Wild A5, A6, Williamson-Ross Multiplex and other stereocomparators. Short base equipment is awaited.

Research is in progress along several lines, and it is of interest to note that some of these are outside map-making. The main subjects are:—

1. STEREOCOMPARATOR MEASUREMENTS AND TILT DETERMINATION.

Investigations have been in progress for some time, with the object of statistical analysis of the radial-line method of tilt determination with particular reference to

(a) computational methods;
(b) Stereocomparator techniques;
(c) simplification and acceleration of routine computation;
(d) statistical analysis of observations.

The work has developed along the following lines:—

(a) Investigation of selection of minor control for radial line plotting;
(b) Investigation of the Hotine method of relative tilt-determination by want of correspondence measurements as modified during the war for radar-survey, with a view to avoiding the necessity for successive approximation other than by tabular or mechanical means;
(c) A tabular method has been developed, but since the formulae for computation can be reduced to fractions having recurring numbers, a mechanical numerical storage device has been evolved which can be attached to a computing machine. This has many other applications, among which are field transformation of co-ordinates;
(d) Statistical analysis of groupings of points observed by the stereocomparator team at the Ordnance Survey, without whose co-operation this part of the work would not be possible.

2. ALTIMETRY.

Arising out of experimental work on the employment of radar fixes for mapping from air photographs, where the errors in determination of altitude, both relative and absolute, limited the practical application, a research program is in progress on a long term basis. A comprehensive analysis of the problem is well in hand. An aircraft is in process of installation with test equipment of various types for precise assessment of relative altitude. External methods of measurement are to be used to provide checks. It is hoped in the first stages, to be able to use these results to facilitate multiplex technique when mapping Colonial territories from radar controlled photography.

3. RADIO AIDS TO SURVEYING.

In addition to general analytical work, on radar ranging and radar fixation, including velocities of propagation, close contact is maintained with developments of the Decca Navigator and assistance given in experimental work.

4. HEIGHTING BY SIMPLE METHODS.

Various researches are in hand to facilitate and improve heighting by simple methods. In particular, for mechanical solution for correction of the deformed datum plane due to tilt; and of development of the "floating plane" method for form-lining.

5. MEDICAL PHOTOGRAMMETRY.

The application of stereo-photogrammetry to medical problems is exciting great interest, and work is in hand in conjunction with University College Hospital. In particular, at present, attention is being given to progress of pregnancy and cancerous growths.

6. ENGINEERING APPLICATIONS.

The following engineering applications of stereo-photogrammetry are being developed in connection with particular researches in the Faculty of Engineering:—

(a) Deflection of Structural Models under loading;
(b) Hydraulic Models;
(c) Traffic Engineering.

## WILD, HEERBRUGG, SWITZERLAND

In the course of the past few years, statements have repeatedly been made in photogrammetric publications to the effect that the manufacture of objectives for photogrammetric cameras had achieved such a high standard, that any improvement with regard to the resolving power would hardly be possible. It was said that all objectives, whether they were of British, American, German or any other manufacture, were practically equal in quality, and that the work performed by the various mathematical and optical research laboratories had reached the same high level everywhere.

It has even been possible to establish an empiric formula with which to calculate the resolving power of photogrammetric objectives in lines per mm., independently of the type of objective, merely on the basis of the focal length, the diaphragm aperture and the angle of aperture. This formula corresponds to a very high degree to the practical results obtained with the photogrammetric lenses used up to this date.

While these statements were made in the current literature, it was already a known fact at the WILD Laboratories that the calculations made in the optical field up to then did not indicate a climax, but rather a stagnation. It was known beyond doubt, and had been proven, that the quality of optical systems for photogrammetric purposes could be improved to a remarkable extent. During several years of extensive researchwork in the optical laboratories of the WILD plant, Mr. L. Bertele, the well-known designer of a number of highly luminous objectives, has developed a new type of photogrammetric objectives, the "AVIOTAR" lens. This new design invalidates every known formula and all the experiences made heretofore with regard to the resolving power. Thus, WILD Heerbrugg is still leading in the field of photogrammetry, regardless of strong competition.

The AVIOTAR is a so-called normal-angle objective with a field angle of 60°, and its aperture of $f/4.2$ is greater than that of all photogrammetric objectives in existence to date. Therefore, it is possible to use the AVIOTAR under much less favorable light conditions than any other objective. Regardless of the unsurpassed luminosity, the resolving power for poor contrasts on aerial photographs has been improved by about 70%. However, not only the quality of the image, but also the absence of distortion for all practical purposes, made the AVIOTAR the leading photogrammetric objective. The maximum distortion is smaller than 5 micron for a focal length of 170 mm. In other makes of photogrammetric objectives, the distortion varies with the diaphragm aperture; this is not the case with the AVIOTAR. Under favorable conditions, the diaphragm can also be closed somewhat, which brings about an additional improvement of the already very high quality of the picture.

The AVIOTAR is chiefly used with the new fully-automatic plate camera WILD RC7 (focal length 170 mm, plate size 150×150 mm), for pictures requiring a very high degree of accuracy. Upon request, it can also be mounted in the normal cone of the fully automatic camera WILD RC5 for films 180×180 mm. This special AVIOTAR Lens has a focal length of 210 mm. Also on this camera it has shown outstanding results. The excellent quality of the image to the very edges considerably increases the possibilities for enlargement for photographic maps as well as for stereoscopic plotting. As an average, one can figure with an improvement of 70% for enlargements and with an increase of 50% of the plotting accuracy. Therefore, for the same plotting scales and the same requirements with regard to accuracy, it is possible to fly at much higher altitudes, and thus to increase the economy of the pictures to a considerable extent.

The quality of the original negatives appears most advantageous in the Autographs and plotting machines because of the extraordinary amount of reproduced detail and because of the brilliancy unachieved heretofore.

# PART II—RESEARCH

*E. L. Merritt,*

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## I. INTRODUCTION

In general, the ultimate in any science is a set of nomenclature, theorems, formulas, and instruments that are near universal, near exact, and near certain. There is a general agreement among men doing research that currently truth is simply the preponderance of probability, or that which has the greatest frequency of agreement. Therefore any body of knowledge is no more than the springboard to some newer body of knowledge that will have been found to have a greater preponderance of probability. In many fields of science, for all practical purposes, an approach to the ultimate—that is, standardization and crystallization of nomenclature, theorems, formulas, and equipment—has been attained. But to standardize and crystallize a science prematurely—that is, before all avenues have been explored and investigated—is certainly unscientific in that it closes the door to further inquiry. I think we can agree that the science of photogrammetry is in its infancy; therefore, an attempt at standardization as an end in itself may actually be harmful. There can be no doubt that there are many untouched reservoirs of investigation in the field of photogrammetry. If we can attach any validity to the foregoing statements, then any such fragmentary comment as "This organization or individual is not conducting its or his research along orthodox lines" is immature.

These preliminary remarks are meant to frame the spirit of this paper and