TEACHING OF BASIC PHOTOGRAMMETRY

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I. Introduction

DURING the past two and one-half years the writer has been instructing a War Training Course in Aerial Photogrammetry at George Washington University. The purpose of this article is to discuss the manner in which the course was presented with the hope that the information be of some value to those who may be called upon to teach similar courses in the future. Due to the increase in the use of aerial photographs for engineering and military purposes, it is most probable that courses in photogrammetry will soon be offered in all progressive engineering colleges.

The scope of any particular course necessarily will have to be adjusted to fit the needs and qualifications of the students. In this discussion we will assume that the students are familiar with topographic drafting, trigonometry, and plane surveying, and that they are interested in obtaining a basic knowledge of the entire field of aerial photogrammetry, with special emphasis on practical map compilation. The order of presentation of the various subjects will be as follows: Equipment required, suggested course outline, and general textbooks.

II. Equipment Required

Generally speaking, schools starting courses in photogrammetry have a limited budget for equipment. Although the cost of many photogrammetric instruments runs into thousands of dollars, those necessary to teach the basic principles can be obtained at a reasonable figure. A suggested list of equipment for a class unit of fifteen students will be given, together with the approximate cost of each item. A list of known manufacturers of these instruments will be found at the end of this section.

Many of the instruments to be included in this discussion are used extensively by the armed forces, and therefore are rather difficult to obtain at the present time. Even with a high priority rating, the purchaser may have to wait months for delivery. For this reason, suggestions are given on substitute equipment which can be constructed in any school workshop and which require the use of very little critical material.

Lens Stereoscopes (15 required)

Illustrated in Figure 1 are several types of lens stereoscopes. Type "A" is convenient for carrying in the pocket, but has the disadvantage of resting directly on the photographs, thereby interfering with their adjustment. Type "B" is less portable than "A" but has the advantage of completely clearing the photographs. The cost of both of these types is approximately ten dollars. Type "C" is a simple improvised folding stereoscope equipped with "dimestore" lenses. The total material cost of this unit is about seventy-five cents. Another type of lens stereoscope (not illustrated) is mounted on a small plywood base. Such an arrangement is very convenient for field use. Although lens stereoscopes give considerable magnification (about 3X), their field of view is rather small.

Mirror Stereoscopes (3 required)

The price of mirror stereoscopes of all-metal construction ranges from forty to two hundred dollars. Although the cheaper type (having back-surfaced mir-

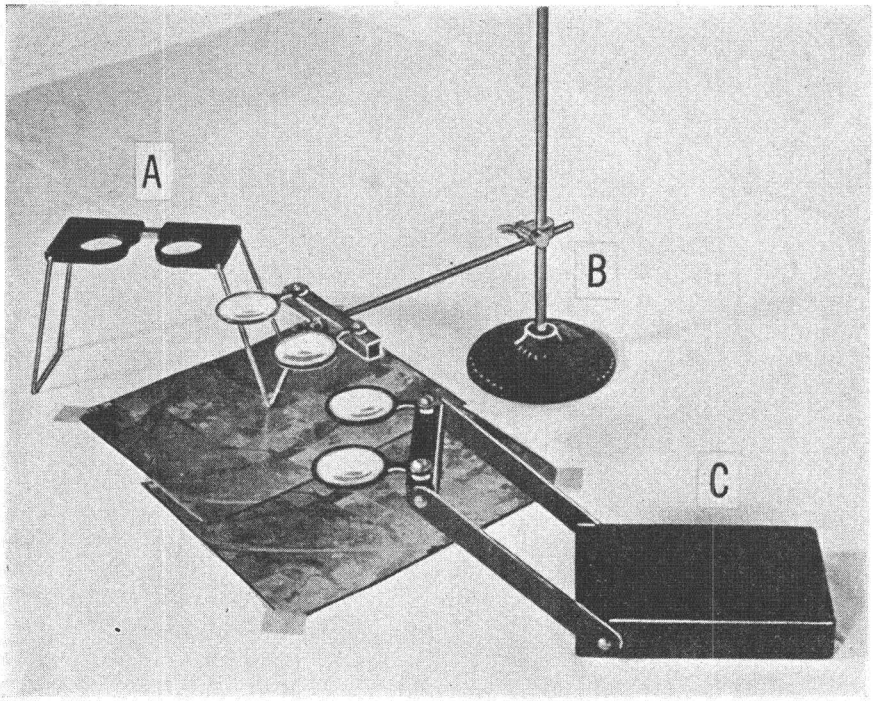


FIG. 1. Types of lens stereoscopes. (A) Folding pocket model. (B) Desk model which completely clears the photographs. (C) Improvised wood model.

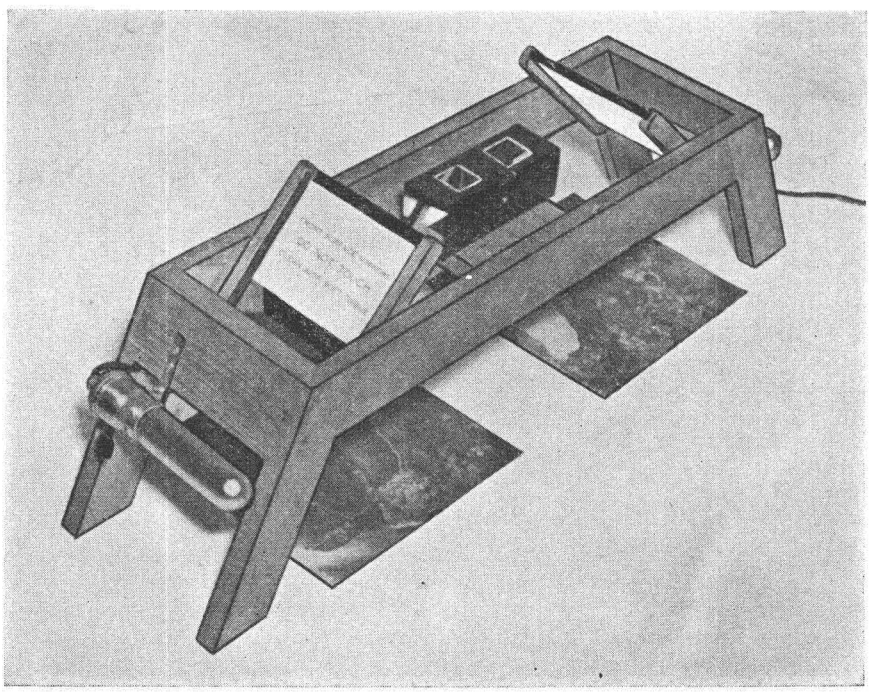


FIG. 2. Mirror stereoscope of simple wood construction.

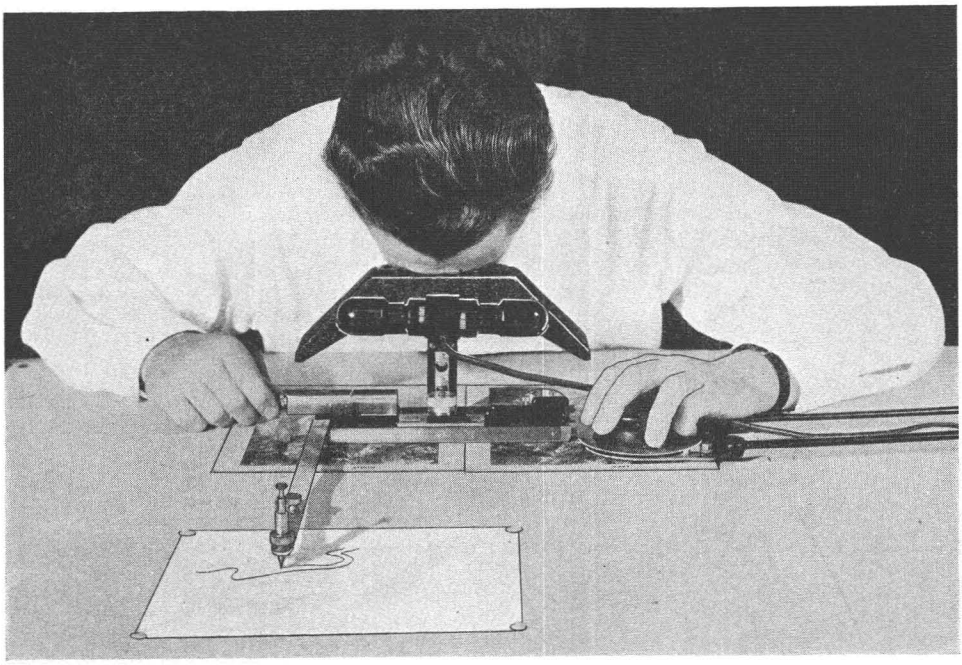


FIG. 3. Fairchild Stereocomparagraph in operation.

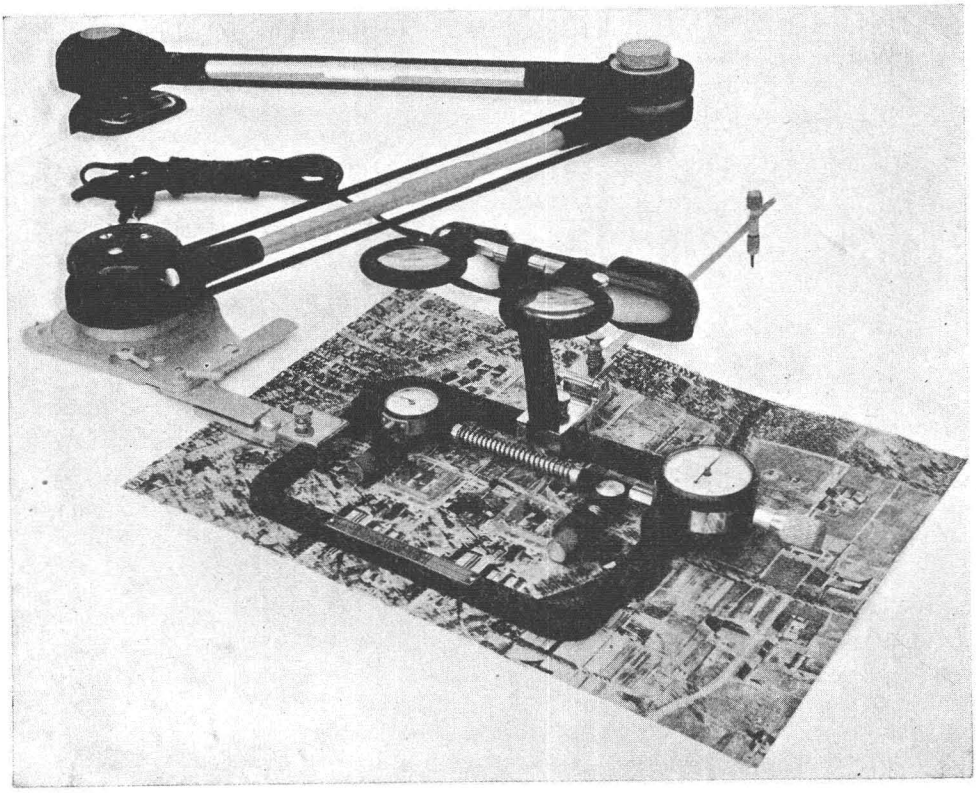


FIG. 4. Abrams Contour Finder ready for operation.

rors) produces a slight ghost image, it probably is less apt to be injured by students than the front-surfaced type. To obtain higher optical performance the more expensive stereoscopes are equipped with front-surfaced mirrors, and right angle reflecting prisms often replace the small eye mirrors. Also provision is sometimes made for adding a magnifying lens system (see stereoscope shown later in Figure 5). Shown in Figure 2 is a wood stereoscope of rather simple con-

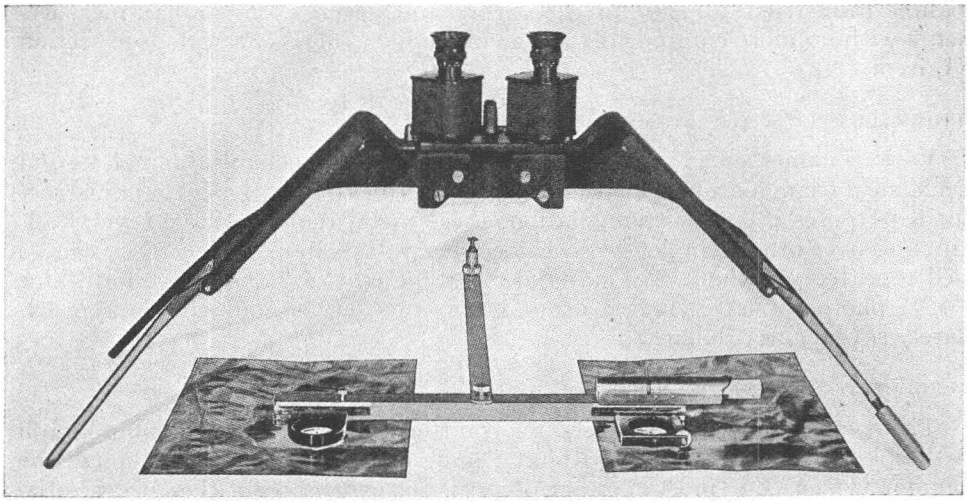


FIG. 5. Fairchild Parallax Bar with magnifying stereoscope.

struction. The model illustrated is equipped with front-surfaced mirrors (cost of 4 mirrors about five dollars) and an attached illuminating system. Ready-made stereoscopes of this type can be obtained at a cost of approximately twenty dollars. Mirror stereoscopes must be used when large photographs are to be examined, or when a large field of view is desired. Their magnification is usually less than unity.

STEREOCOMPARATORS (1 required)

In this discussion will be included only those simple types in which the floating marks rest directly on the photographs (see Figures 3 and 4). Instruments of this nature are used for the determination of elevations and the drawing of contours on overlapping vertical photographs. It is the cheapest and simplest instrument available for training persons in stereoscopic plotting. However, the following limitations must be considered: (1) Accurate results cannot be obtained from tilted photographs unless rather tedious correction factors are applied to the parallax values; (2) an error is caused by a difference in scale of the photographs; (3) the contours drawn show a perspective view of the terrain rather than an orthographic or map view; (4) the distortion of the photographic paper often introduces considerable error.

When drawing contours it is highly desirable that the stereocomparator be attached to an alignment mechanism (such as a standard drafting machine) in order that the eye base of the instrument remain parallel to the air base on the photographs as the observer moves the floating mark over the stereoscopic model.

An instrument related to a stereocomparator is the "parallax bar" (see Figure

5) or "tracing stereometer." This is a parallax measuring device similar to the floating mark assembly on the above stereocomparators. It can be used with almost any mirror stereoscope, thus keeping the cost of the complete unit to a minimum.[1] The cost of a stereocomparator (also called stereocomparagraph or contour finder) ranges from 250 to 300 dollars. Drafting machines to use with these instruments cost from forty to ninety dollars. The cost of a parallax bar is about eighty dollars. In case a stereocomparator cannot be obtained, it is still possible to instruct students in the theory and practice of parallax measurements with no more equipment than a twelve-inch engineer's scale (see section III, item 11).

SPIDER TEMPLETS (75 units—optional)

Various names such as radial intersectors,[2] slotted mechanical templets, and mechanical triangulators have been used to describe this equipment. For instructional purposes in radial triangulation, these metal templets have several advantages over other templet systems (see section III, item 8) since they can be used repeatedly without any material loss. The cost of 75 complete units (for 9″×9″ photographs) including arms, bolts, nuts, studs, and pins is approximately seventy-five dollars.

REFLECTING PROJECTORS (one—optional)

This type of instrument is used for transferring detail from the photograph to the plotting sheet, with or without a scale change as desired. Although the common type used in most mapping offices is too expensive for class use, a satisfactory low-priced substitute is found in the "vertical sketchmaster" illustrated in Figure 6. This portable instrument, based on the camera lucida principle, was designed for field use by J. L. Buckmaster of the U. S. Geological Survey. Its adjustments are arranged to take care of scale changes (from 0.25 to 1.5) and approximate tilt removal. Its cost is about one hundred dollars. An oblique sketchmaster has also been designed for transferring detail from oblique photographs.

MULTIPLEX EQUIPMENT (optional)

Although this type of equipment is highly desirable for instructional purposes, its relatively high cost places it outside the budget of most educational institutions (unit complete with three projectors costs about five thousand dollars). After the war it is quite possible that excess or obsolete equipment of this type may be obtained from the armed services. The writer had a wood model of the multiplex equipment constructed which has proved very valuable for lecture use (see Figure 7). The cords (red and green) represent light rays from various ground points. Six of these points have been chosen in the common overlap area, and are arranged in a manner similar to those chosen for relative orientation in the actual multiplex equipment. When not in use, the model can be readily dismantled and packed in a 27-inch fiber luggage case.

MISCELLANEOUS EQUIPMENT

Each student should be required to have the usual drawing instruments needed in any mechanical drafting class, also a magnifying glass and a needle point. The following additional equipment should be available for class use: beam compass, drop bow pen, assorted scales and straight edges. A lantern slide

[1] For further illustrations and descriptions of above mentioned stereoscopic instruments see PHOTOGRAMMETRIC ENGINEERING, Vol. VIII, No. 3, pages 181–202 (1942).

[2] Buckmaster, J. L., "Application of the Radial Intersector in the Topographic Branch of the Geological Survey," PHOTOGRAMMETRIC ENGINEERING, Vol. VIII, No. 4, pages 235–239 (1942).

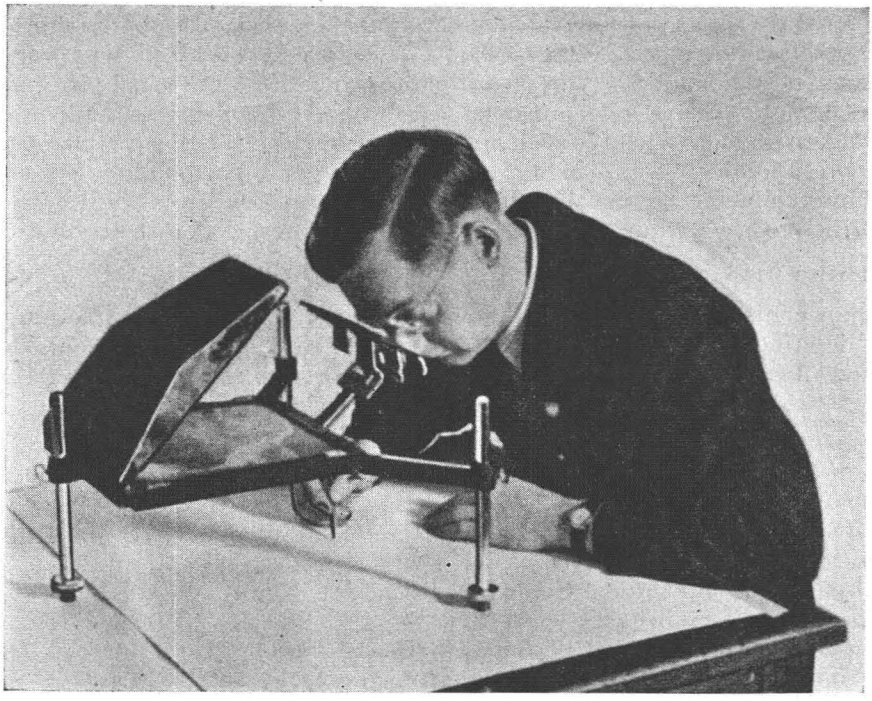


FIG. 6. Vertical sketchmaster in operation.

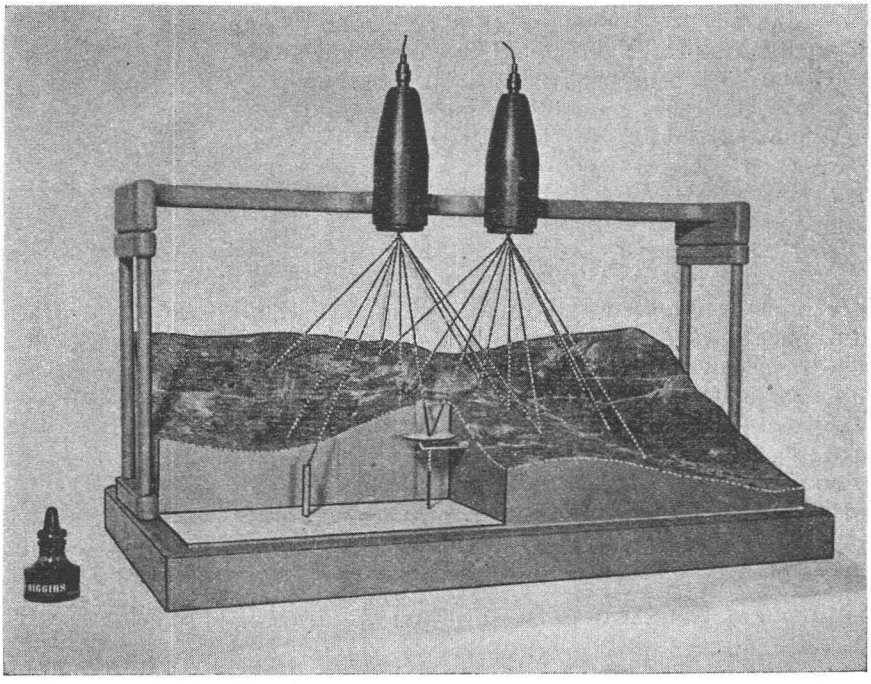


FIG. 7. Model of Multiplex equipment for lecture use.

projector and a variety of slides should be available for class use. Also samples of aerial photographs of many types should be secured. Due to present war restrictions, it is difficult to secure aerial photographs from the usual peace-time sources. Among these were commercial aerial survey organizations, and various Federal Government agencies such as the Agricultural Adjustment Administration, Forest Service, Geological Survey, etc. Instructors of War Training Courses in Photogrammetry are usually able to obtain permission from local military authorities to use certain available photographs covering non-strategic areas.

Equipment Manufacturers

Following is a list of concerns (known to the writer) which manufacture the above described equipment. No attempt is made to list all the photogrammetric products of each concern, but only those items pertinent to the present discussion:

Abrams Instrument Company, Lansing, Michigan.
Lens stereoscopes, contour finders, mechanical triangulators, vertical and oblique sketchmasters.

Aero Service Corporation, 236 East Courtland St., Philadelphia, Pennsylvania.
Vertical and oblique sketchmasters.

Bausch and Lomb Optical Company, Rochester, New York.
Multiplex equipment.

Evaporated Metal Films Corporation, Ithaca, New York.
Front-surfaced and semi-transparent mirrors.

Fairchild Aviation Corporation, 88-06 Van Wyck Blvd., Jamaica, New York.
Mirror stereoscopes, stereocomparagraphs, parallax bars.

Graves, H. W., 4535-18th St., North, Arlington, Virginia.
Relief models, instrument models (see Figure 7).

Kalart Manufacturing Company, Inc., Stamford, Connecticut.
Slotted mechanical templets, oblique sketchmasters.

Keuffel and Esser Company, Hoboken, New Jersey.
Drafting machines, general drafting supplies.

MacMillan, J. F., 1802 Key Blvd., Arlington, Virginia.
Mirror stereoscopes (wood only).

Ryker, Harrison C., Inc., 365-5th St., Oakland, California.
Lens and mirror stereoscopes.

III. Suggested Course Outline

Since photogrammetry is a rapidly changing science, any plan of study should frequently be modified to bring it up to date. Consideration should also be given to special circumstances in some localities which make it desirable to stress one particular branch of photogrammetry, in which case the outline given below will have to be so modified. This outline is based on 60 two-hour class periods (30 lectures and 30 laboratory or drawing room sessions). In a regular college course this is equivalent to six semester hours credit. It might be possible to cut this time in half if only the elementary aspects of the subject are to be presented. The below sequence of class periods has been arranged so as to coordinate the various subjects as much as possible.

1. Geometrical Characteristics of Aerial Photographs

(*4 hours lecture and 6 hours laboratory*) Scale relationships, coverage, perspective qualities, relief and tilt displacements, methods of tilt determination for

nominally vertical photographs. (Note: The use of a three-dimensional model is very helpful in explaining the geometry of the photograph. A model of this nature, printed on white cardboard, has been designed by O. M. Miller of the American Geographical Society, New York.)

Problem A: Construction of a tilt diagram. The example shown in Figure 8 may be used for several purposes; (a) it furnishes a simple graphical method of introducing the subject of tilt, (b) the tilt displacement at the corner of the square may be mathematically computed to check the graphical solution, (c) computations can be made for an optical rectification which will restore the distorted shape to a true square.

Problem B: Tilt determination[3] on a photograph to be furnished each student. If sufficient photographs are not available, the instructor can work up a tilt problem from a selected photograph, and then transfer the ground points and principal point to a sheet of drawing paper for each student. If time is available it would be preferable to require the problem to be solved by more than one method.

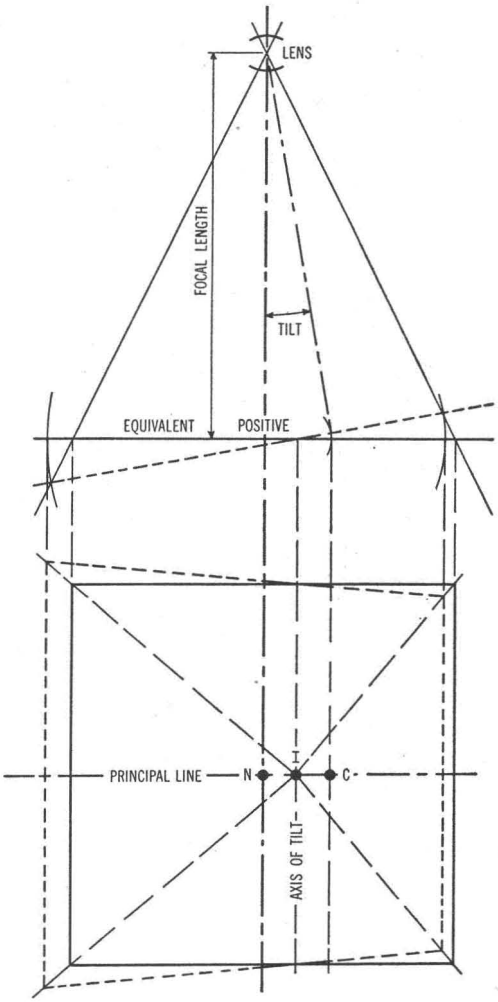


FIG. 8. Diagram showing the effect of tilt in the image of a square object. Principal point denoted by "C," isocenter by "I," and nadir point by "N."

2. PHOTOGRAMMETRIC OPTICS[4]

(*4 hours lecture and 2 hours laboratory*) Introduction to lenses, optical rectification, errors caused by glass plates, simple optical systems, color filters, prisms, mirrors.

Problem C: Optical rectification of a tilted photograph. Compute rectification data for removing the tilt from a given photograph. If desired, the distorted shape shown in Figure 8 can be rectified back into a true square. Draw to scale a schematic view of the rectifying camera.[5]

[3] Anderson, R. O., "Applied Photogrammetry," (1941), 190 pages, $3.00. Copies can be obtained from author whose address is 401 Pound Bldg., Chattanooga, Tenn.

Church, Earl, "Analytical Computations in Aerial Photogrammetry," PHOTOGRAMMETRIC ENGINEERING, Vol. VII, No. 4, pages 212–252 (1941).

[4] Ask, R. E., "Elements of Photogrammetric Optics," PHOTOGRAMMETRIC ENGINEERING, Vol. IX, No. 1, pages 36 through 66 (1943).

[5] See footnote reference 4, page 51, fig. 12.

3. Aerial Cameras and Accessories[6]

(*2 hours lecture and 2 hours laboratory*) Single and multiple lens cameras, types of shutters, film flattening devices, film winding mechanisms, recording devices, view finders, intervalometers, mounts, auxiliary horizon cameras, statoscopes, equipment for night photography. One laboratory period should be devoted to a demonstration of aerial camera equipment. Arrangements for such an exhibit can often be made with a nearby camera user or manufacturer.

4. Flying for Photography

(*2 hours lecture and 2 hours laboratory*) Job specifications, preparation of flight map, cost estimates, aircraft requirements, special navigating instruments, making the exposures.

Problem D: Preparation of a flight map and estimate of time and material needed for a specific job. It is desirable that each student be furnished with a 1:125,000 scale quadrangle map for this problem.

5. Photographic Materials, Chemistry, and Laboratory Technique[7]

(*2 hours lecture and 2 hours laboratory*) Properties of photographic emulsions, types of film base, color filters used with various emulsions, processing of aerial film, characteristics of photographic papers, contact and projection printing, preparation of photo-index map. If possible, arrange an inspection tour through an aerial photographic laboratory.

6. Introduction to Stereoscopy[8]

(*2 hours lecture and 2 hours laboratory*) The human eye and binocular vision, stereoscopic vision, simple lens and mirror stereoscopes, orientation of photographs for stereoscopic observation, pseudoscopic effect, stereoscopic training and testing, anaglyphs, vectographs. The purpose of this lecture is to present the fundamentals of stereoscopy and to train the students in the use of simple stereoscopes. A thorough discussion of parallax measurements will be presented later under item (11). The laboratory period should be devoted to practice in the use of various types of stereoscopes,[9] and stereoscopic vision tests. In regard to the last item, it is obvious that only those individuals possessing normal binocular vision can operate a stereoscopic plotting instrument.

7. Review of Surveying Fundamentals

(*2 hours lecture and 2 hours laboratory*) Map projections,[10] ground control, representation of planimetric and topographic details.

[6] Talley, B. B., "Engineering Applications of Aerial and Terrestrial Photogrammetry," pages 42–133.

Report on Air Photography, Photogrammetric Engineering, Vol. IV, No. 3, pages 117–192 (1938).

[7] Mack, J. E., and Martin, M. J., "The Photographic Process," (1939), McGraw-Hill Book Co., Inc., New York.

Neblette, C. B., "Photography," (1939), D. Van Nostrand Co., Inc., New York.

[8] Nowicki, A. L., "Stereoscopy," Photogrammetric Engineering, Vol. VIII, No. 3, pages 181–202 (1942).

Judge, A. W., "Stereoscopic Photography," (1935), American Photographic Publishing Co., Boston, Mass.

Polaroid Corporation, 730 Main Street, Cambridge, Mass. Specimen vectographs, made from aerial negatives, may be secured from this organization.

[9] Fairchild Aviation Corp., "Practical Stereoscopy for the Beginner," 29 page booklet (1943).

[10] Deetz, C. H., and Adams, O. S., "Elements of Map Projections," special publication No. 68, U. S. Coast and Geodetic Survey. Copies may be obtained from Superintendent of Documents, Washington, D. C. $1.00.

Polyconic Projection Tables, special publication No. 5, U. S. Coast and Geodetic Survey. Copies may be obtained from Superintendent of Documents, Washington, D. C. $0.30.

Problem E: Construct projection and plot ground control for radial triangulation problem which follows. Grained cellulose acetate sheeting should be used. This sheeting may be obtained from the Eastman Kodak Co., Rochester, N. Y., or from The Lustro Co., 117–125 East 13th St., Chicago, Ill.

8. RADIAL PLOTS[11]

(*4 hours lecture and 18 hours laboratory*) Control requirements, field inspection, preparation of the photographs including determination of average scale, discussion of various types of templets, adjusting of templets to fit ground control, compilation of detail, use of map projectors, drafting procedure.

Problem F: Construction of a radial plot. Each student should be supplied with a strip of at least five 9″×9″ photographs printed on low-shrink paper. It is desirable that the terrain covered by these photographs be rather rugged (elevation differences of at least 1000 feet on 1:20,000 scale photographs) in order to vividly demonstrate the theory of the method. A reasonable amount of culture should be present for detailing purposes. Properly distributed horizontal ground control should also be available. It is suggested that three well distributed control stations be located on the first photograph, and one or two on the last. In order to check the student's work it is convenient to have an accurate map of the same region. Some instructors may find it desirable to have the class as a whole work on a much larger problem than suggested above. For instance, five strips of fifteen photographs may be used, each student being responsible for a certain section of the job. The advantage of a problem of this type is that a study of the effect of control distribution can be made. A word of caution is necessary, however, in that careless work by one student can upset the accuracy of the entire plot.

In regards to templets used for this problem, three types are available: (a) clear cellulose acetate templets—requires no special equipment for their construction and is therefore the easiest and cheapest to obtain, although the least desirable from a practical standpoint, (b) slotted cardboard templets—requires the use of a special patented slot cutter, (c) spider templets—has a high initial cost but can be used repeatedly with no material loss, and is considered the best type for instructional purposes.

In compiling detail, standard map symbols should be used throughout.[12] The use of a vertical sketchmaster (shown in Figure 6) is very helpful for this operation. In regard to lettering, the use of printed type on transparent gummed tissue is preferred. The style of type used for each feature should conform with standard mapping practice. Prepared lettering of this nature can usually be secured from the larger printing establishments.

9. MOSAICS

(*2 hours lecture and 2 hours laboratory*) Uses, classification as regards control, preparation of the photographs, laying technique, finishing, reproduction. The laboratory period should be devoted to a demonstration of mosaic construction by a well qualified person.

If the instructor desires to emphasize mosaic work in the course, the compilation of detail in the above radial triangulation problem can be omitted. In its

[11] Kelsh, H. T., "The Slotted Templet Method" misc. publication No. 404, U. S. Department of Agriculture. Copies may be obtained from Superintendent of Documents, Washington, D. C. $0.15.

McCurdy, P. G., "Manual of Aerial Photogrammetry," (1940), Hydrographic Office, Navy Department, pages 43–57.

[12] War Department field manual, "Conventional Signs, Military Symbols, and Abbreviations," FM 21-30 (1939). Copies may be obtained from Superintendent of Documents, Washington, D. C., $0.20.

place can be substituted the construction of a controlled mosaic, using the radial plot as a base.

10. INTERPRETATION OF AERIAL PHOTOGRAPHS[13]

(*2 hours lecture and 2 hours laboratory*) Study of objects in regard to size, shape, shadows, tone, and texture. Identification of military installations, detection of camouflage, use of infra-red and color films, night photography with flash bombs. It is highly desirable that the students be furnished with photographs of nearby areas, so that actual field interpretation studies can be made.

11. STEREOSCOPIC PLOTTING INSTRUMENTS[14]

(*12 hours lecture and 10 hours laboratory*) Absolute and differential parallax, parallax equations and tables, the stereocomparator,[15] the Brock process, the multiplex equipment,[16] the aerocartograph, the stereoplanigraph, the autograph, etc., relative merits of various types of stereoscopic plotting instruments.

Problem G: Contouring of vertical photographs. Contours are to be drawn on the same vertical photographs as were used for the radial plot. A stereocomparator is to be used if available. In case this instrument cannot be obtained, it is still possible to instruct students in the theory and practice of parallax measurements with no more equipment than a twelve-inch scale (preferably one with 0.01″ subdivisions). In regard to contour accuracy, it is not likely that the lack of precision of this method will be much greater than that caused by tilt or paper distortion in stereocomparator work. However, the use of a scale cannot compete with a stereocomparator for the determination of heights of relatively small objects such as buildings, trees, etc. The following procedure is suggested for using a scale: (a) with the aid of a straight edge, line up the principal point bases of two overlapping photographs, separating corresponding points any convenient distance but slightly less than the length of the scale and tape in position; (b) measure the distance on the photograph between corresponding points of known elevation (at least three well distributed points are desired in the overlap region); (c) plot a graph with elevations on vertical axis and measured distances on horizontal axis (Note: The difference in distance between any two pairs of corresponding points is the difference in parallax of these points. However, it is not necessary to make this subtraction if the graph is plotted as mentioned above); (d) measure the distance between any pair of corresponding points whose elevation is desired, enter this distance on the graph and read off the corresponding elevation; (e) contours may be sketched in after the elevation of a sufficient number of critical points have been determined. In order to secure a better representation of the relief, it is very desirable to use a stereoscope when selecting the critical points and also when sketching the contours. The contours

[13] Eardley, A. J., "Aerial Photographs—Their Interpretation and Use," (1942), Harper and Brothers, New York. This book gives emphasis to geologic interpretation.

War Department field manual, "Military Intelligence—Role of Aerial Photography," FM 30-21 (1940).

[14] Talley, B. B., "Engineering Applications of Aerial and Terrestrial Photogrammetry," pages 484–551.

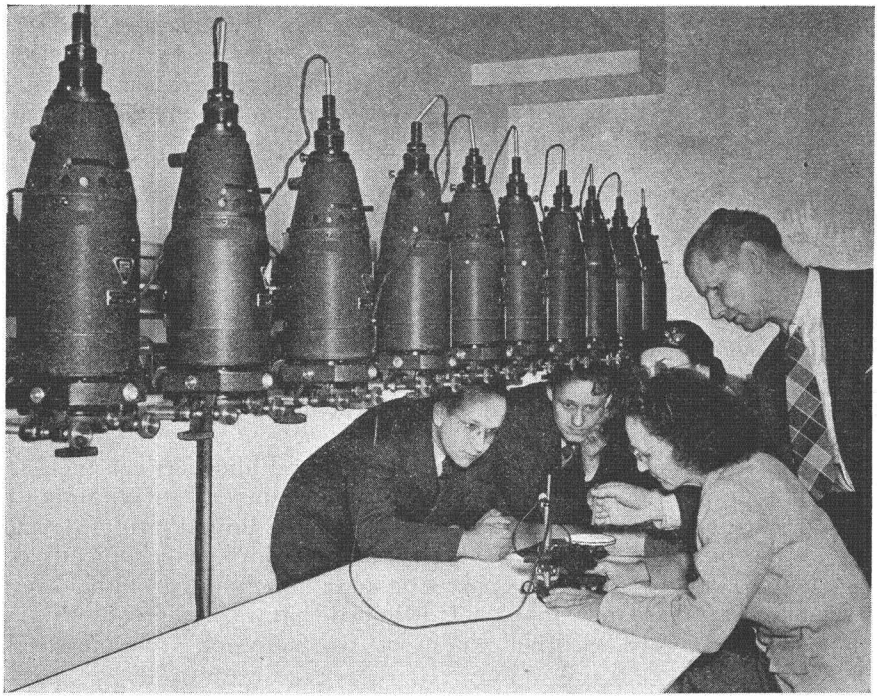
Von Gruber, O., "Photogrammetry," (1932 English translation), pages 276–375.

[15] Engineer School, Fort Belvoir, Virginia, "Instruction Manual for the Stereocomparagraph," (1940).

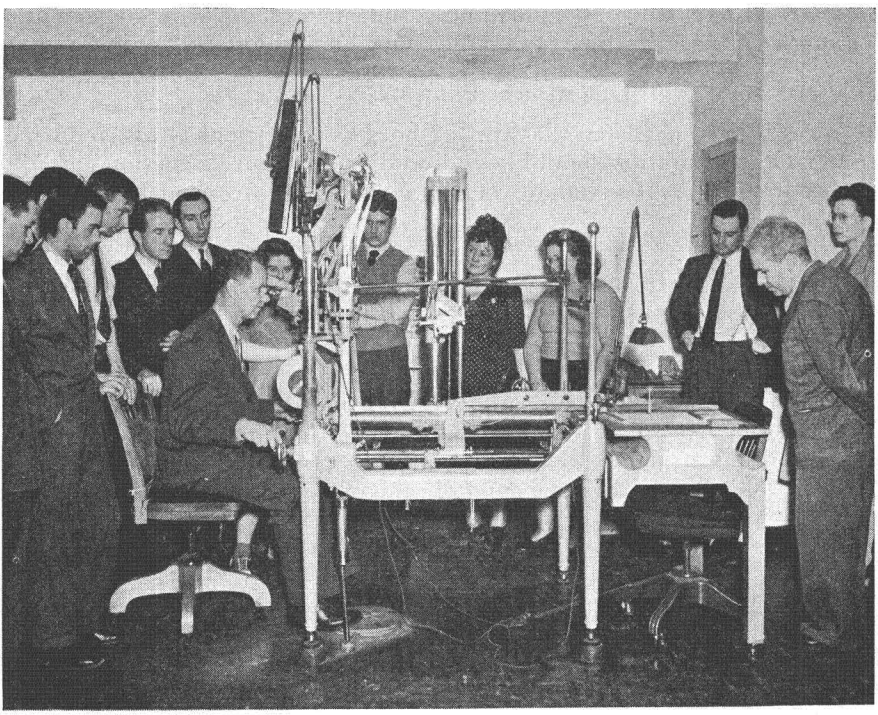
McCurdy, P. G., "Manual of Aerial Photogrammetry," (1940), Hydrographic Office, Navy Department, pages 58–64 and 90–102.

Sanders, R. G., "Elementary Elevation Determination From Aerial Photographs," Photogrammetric Engineering Vol. IX, No. 1, pages, 22–34 (1943).

[16] Engineer Detachment, Wright Field, Dayton, Ohio, "Multiplex Operators Manual."



(a)



(b)

FIG. 9. Class inspection tour of Clarendon, Virginia, office of the U. S. Geological Survey. (a) Multiplex equipment. (b) The Aerocartograph.

as sketched on the photographs represent a perspective view of the terrain. Their true plan position can be found as follows: (a) Locate by intersection, on the previously run radial plot, the plan position of the critical points (spot heights) on the photographs, (b) adjust the contours to these points in the same manner as was previously used in tracing off detail such as crooked roads or streams.

12. Mapping from Oblique Photographs[17]

(*4 hours lecture and 10 hours laboratory*) Uses, geometrical relationships, graphical determination of horizontal and vertical angles, perspective grids. Instrumental methods including the Wilson photoalidade, the Miller single eyepiece plotter, and others.

Problem H: Construction of perspective grid, using a high oblique photograph of flat terrain. Using this grid, transfer the detail from the photograph to the plotting sheet.

Problem I: Graphical determination of horizontal and vertical angles from oblique photographs. An instrument of recent development for obtaining horizontal angles from oblique photographs is the "Rectoblique Plotter" developed by J. G. Lewis of the U. S. Geological Survey. This plotter mechanically determines horizontal angles to various points on an oblique photograph and records them graphically on a paper templet. It is hoped that a complete description of this instrument, as well as other phases of "tri-metrogon" mapping, will be published soon.

13. Further Applications of Photogrammetry

(*4 hours lecture*) Geology[18] and mining, soil surveys, forestry, route planning, water supply and sanitation, tax studies, city and regional planning, etc.

14. Examination and Discussion Periods

(*12 hours*) It is suggested that three 2-hour examinations be given during the course. Each examination should be followed by a 2-hour discussion period. The writer has found that the students benefit considerably from such discussions.

15. Inspection Tour of a Mapping Agency

(*2 hours*) On tours such as these (see Figure 9) students see practical applications of the various principles discussed in class lectures.

IV. General Textbooks

Information concerning current books on photogrammetry is given below. Included in this list are several surveying books with one or more chapters on the subject. Each student should be required to have a copy of the selected class text. It is also desirable that one copy of each of the books listed be obtained for reference use.

[17] Wilson, R. M., "Oblique Photographs for the Surveyor," Photogrammetric Engineering Vol. VIII, No. 1, pages 36–54 (1942).

Wilson, R. M., "Oblique Photographs and the Photoalidade," Photogrammetric Engineering, Vol. IV, No. 2, pages 65–74 (1938).

Miller, O. M., "Topographical Mapping from High Oblique Air Photographs," Photogrammetric Engineering Vol. VIII, No. 1, pages 55–79 (1942).

Department of the Interior (Canada), "The Use of Aerial Photographs for Mapping," Topographical Survey Bulletin No. 62, pages 12–31 (1932).

[18] Smith, H. T. U., "Aerial Photographs in Geomorphic Studies," Photogrammetric Engineering Vol. VIII, No. 2, pages 129–155 (1942).

American Society of Photogrammetry, "Manual of Aerial Photogrammetry." This is being published by the society with the co-operation of specialists in the various branches of the profession. A proposed list of contents is given in PHOTOGRAMMETRIC ENGINEERING, Vol. VII, No. 4. Up to the present time seven chapters have been completed, including one devoted to the definition of terms used in photogrammetry (see Vol. VIII, No. 4). After the chapters have been published individually, it is the intention of the society to publish the complete set in book form, making the necessary revisions to properly co-ordinate the various subjects.

Bagley, James W., "Aerophotography and Aerosurveying," (1941), 324 pages, $3.50, McGraw-Hill Book Co., Inc., New York. It is the opinion of the writer that this is the best textbook on general photogrammetry published in the United States up to the present time. However, the following changes would probably increase its usefulness: Revision of terminology to agree with general usage; revision of chapter on photographic transformation, emphasizing the practical rectification of nominally vertical single lens photographs; inclusion of more information on stereoscopic plotting instruments; inclusion of problems at the end of each chapter.

Breed and Hosmer, "Higher Surveying," (1940), $3.50, John Wiley and Sons, Inc., New York. The section of the book devoted to photogrammetry (152 pages) is intended to form a part of a typical surveying course and does not contain enough material for a course entirely devoted to photogrammetry, unless supplemented by considerable outside material. Considering the limited space available, too much emphasis is placed on terrestrial photogrammetry.

Davis and Foote, "Surveying," (1940), $5.00, McGraw-Hill Book Co., Inc., New York. Contains a chapter of 63 pages on "Photogrammetric Surveying" written by B. B. Talley. The chapter gives a brief but excellent discussion of practically all branches of the subject, and therefore should prove useful as an introduction to photogrammetry in a regular surveying course.

Hart, C. A., "Air Photography Applied to Surveying," (1940), 366 pages, $7.50, Longmans, Green and Co., New York. This book, written by an English author, gives a well balanced presentation of the entire field of photogrammetry with special emphasis on methods and equipment used in the British Empire. The book should prove valuable as a class reference.

Hotine, M., "Surveying from Air Photographs," (1931), 250 pages, printed in Great Britain but copies can be secured through G. E. Stechert and Co., New York. This book contains excellent basic information on all phases of photogrammetry except photography, optics, and types of aerial cameras. Due to the many new developments made in this field in the past twelve years some parts of the book are now obsolete.

McCurdy, P. G., "Manual of Aerial Photogrammetry," (1940), 102 pages, printed by Hydrographic Office, Navy Department. Describes the graphical methods used by this organization for mapping from vertical and oblique photographs. Of special interest is the manner in which the construction of a radial plot is presented, excellent diagrams and halftone reproductions of sample photographs being included to illustrate each step.

Raynor, W. H., "Advanced Surveying," (1941), $3.25, D. Van Nostrand Co., Inc., New York. Contains a chapter of 60 pages devoted to a general discussion of photogrammetry. Should prove useful as an introduction to the subject in a regular surveying course.

Sharp, H. O., "Photogrammetry," (1943), 129 pages ($8\frac{1}{2}\times11$), $3.50, John Wiley and Sons, Inc., New York. This book was prepared by Prof. Sharp for use

as a text at Rensselaer Polytechnic Institute. It is believed that an improvement could be made in this book by rearranging the subjects in a more logical manner. Also information on mosaics, photographic materials, and photographic laboratory technique might be included.

Talley, B. B., "Engineering Applications of Aerial and Terrestrial Photogrammetry," (1938), 612 pages, $10.00, Pitman Publishing Corp., New York. This was the first complete book on photogrammetry published in the United States. It is hoped that a revision will be made sometime in the near future so as to include recent developments. The book is useful as a class reference, especially in the fields of aerial cameras and stereoscopic plotting instruments.

Von Gruber, O., "Photogrammetry," (1932 English Translation), 454 pages, $8,00, American Photographic Publishing Co., 428 Newbury St., Boston, Mass. The greater part of the book is devoted to a thorough discussion of the theory and operation of stereoscopic plotting instruments, and therefore serves as an excellent reference book in this field. Chapters are also included on the geometry of the photograph, aerial camera lenses, and shutters. Practically no information is given on graphical methods of compilation.

Whitmore, G. D., "Elements of Photogrammetry," (1941), 136 pages, $1.75, International Textbook Co., Scranton, Pa. An excellent book on elementary photogrammetry. It is written in such a style that beginners will find no difficulty in understanding the principles presented.

War Department—The following technical and field manuals have been prepared by this organization for use as training texts for army personnel. These manuals may be obtained from the Superintendent of Documents, Washington D. C., at the indicated prices.

"Advanced Map and Aerial Photograph Reading," FM 21-26 (1941), 190 pages, $0.20. Entirely devoted to reading of maps and photographs. It is a desirable text for beginners.

"Basic Photography," TM 1-219 (1941), 342 pages, $0.50. Contains desirable material for those interested in photographic laboratory procedure.

"Topographic Drafting," TM 5-230 (1940), 302 pages, $1.00. In addition to discussing topographic drafting, more than one-half of the text is devoted to map preparation from aerial photographs, with emphasis on drafting procedure. Considerable space is given to the operation of the stereocomparagraph, including parallax tables. If this book is supplemented by other material it would be useful as a text in elementary photogrammetry.

"Aerial Phototopography," TM 5-240 (1941), 104 pages, $0.15. Chiefly devoted to mapping procedure by the multiplex method, and to the preparation of radial plots from tandem T-3A photographs.