FRIDAY AFTERNOON SESSION

JANUARY 23, 1948

The meeting reconvened at one-forty o'clock, President Massie presiding.

PRESIDENT MASSIE: Will the meeting come to order, please. I think all will agree that we have an extremely good Program Committee this year. I cannot name each worker, but I do want to extend the thanks of the entire Society to those who helped to minimize the worries connected with this annual meeting, and I would especially like to extend our thanks to Mr. Kowalczyk, who is the Chairman; Mr. David Landen, who handled the exhibits; Mr. Smart, who has handled registration; Lt. Hagen, of the Navy, who has handled our publicity better than we have ever had it handled before; Mr. Kilmartin, who arranged for transportation to the Federal bureaus; and Mr. Dill, who has put his untiring and unceasing efforts into making this meeting a success. I would like to extend our thanks also to all of the girls who have helped us, and I would like to thank each and all who had anything to do with the preparation of the program for this meeting.

The subject of our first speaker for this afternoon is the "Negative Quality Required for Stereo-Plotting Instruments."*

Mr. William Harmon finished Louisiana State University in 1930. After working on field surveys for two and one half years with the United States Engineers, he transferred to the Tennessee Valley Authority. I am quite sure many of us remember the work that he did there. He was always endeavoring to improve the type of diapositives that we are using in multiplex. He has continued that work.

He is now a member of the Geological Survey, and is at the present time Chief of the Aerial Photography Unit. I do not believe we have anyone who is better qualified to speak on this subject than Mr. Harmon.

MR. HARMON: Due to the ever increasing use of stereo-plotting equipment by both private contractors and Government agencies, it is felt that a discussion on the negative quality required for the use in these instruments is of particular interest at this time. While the photographic quality of all aerial photographic negatives is of the highest importance, it is especially true of the negative to be used in stereo-plotting equipment due to the time and money that will eventually be expended on these negatives for the compilation of the map. In addition its quality greatly determines the quality and accuracy of the resulting map. The negative in this case is comparable to the field notes of the surveyor that are carefully collected by him during the course of the field operations and later used as the basis for the compilation of his map. It is obvious that the more accurate and intelligible information available on the negative, the more complete and accurate will be the final map. This is a point that cannot be overemphasized.

The basic requirements of the negative of this type are, first: it must be exposed in a camera which meets all the requirements and specifications for a precision aerial camera. This camera must have been completely tested and calibrated in order to insure its operation at the highest degree of efficiency. Secondly: ranking in importance with the first point and with reference to the field notebook analogy, the negative must have the highest photographic quality obtainable. Every effort should be made to profit from the results of years of photographic experimentation and to utilize all the accessories which are now available for the securing of a negative having the best possible photographic

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quality. Photographic quality in this case means recording as faithfully as possible the brightness range of the terrain to be photographed, all visible detail, the various colors in monochrome existing at the time of exposure in such a manner that any point on the photograph can be readily identified and accurately measured.

The factors involved in the production of a negative of the proper physical and photographic quality suitable for use in the stereoplotting equipment are quite numerous. It is difficult to assign to any one of these factors greater weight than to others, as each one forms a link of a chain which must be strong and continuous throughout. The information available for the compilation of the map will depend greatly on the strength of the weakest link. The factors mentioned above are as follows:

1. The exposure must be made in a precision camera of specified metrical characteristics.
2. The sensitized emulsion must precisely coincide with the focal plane of the camera at the instant of exposure.
3. The physical characteristics of the emulsion which may be subdivided into:
   A. Speed or response to exposure and development.
   B. Inherent graininess or original size of the unexposed silver particles.
   C. Spectral sensitivity of the emulsion or its ability to record in monochrome faithfully and accurately the different colors which may exist at the time of exposure. This requirement pre-supposes the use of the proper filter.
4. Sharpness and resolution which are dependent upon:
   A. The inherent resolving power of the camera lens.
   B. The inherent resolving power of the emulsion and the degree to which this property is utilized. For instance: filters used, type of developers.
   C. Exposure and type of development.
   D. Mechanical and physical factors, such as speed of the airplane, type of mount in which the camera is placed, and the efficiency of the lens and shutter combination.
5. The exposure time interval which is dependent upon:
   A. Illumination.
   B. The type of terrain being photographed.
   C. The sensitive material and the type of filter.
   D. The type of processing to be used.
   E. Speed of the airplane, and height above terrain.
   F. Efficiency of the lens and shutter combination.

Before analyzing photographic quality it is in order at this point to define briefly the requirements of a precision camera. These are:

1. The cone in which the lens is mounted and which contains a fixed focal plane and accurately set fiducial marks, must be constructed of a metal which has a very low coefficient of expansion in order that the relationship between the focal plane and the rear nodal point of the lens will not be disturbed through a wide range of temperature.
2. A positive means of flattening the film at the instant of exposure. It is of the utmost importance at the present time that some means be incorporated to check the flatness of the film at the instant of the exposure. This is one factor that now causes a great amount of trouble and is far from solution.
3. The platen against which the film is pressed at the instant of exposure must be flat to within .0007″.
4. The shutter should be of the between-the-lens type and should have great dependability and uniformity of operation.
5. The fiducial marks should be so placed that they serve to locate the principal point in the focal plane.

The camera should be accurately tested for compliance with these specifications, and in addition to tests for lens distortion and resolution should be calibrated to give results equivalent to those obtained at the National Bureau of Standards. If for any reason a change occurs in any of the lens settings, the camera should be recalibrated at once. The accurate determination of the principal distance is also of great importance for the compilation of an accurate topo-

graphic map. A test of the camera as an instrument suitable for use in the particular type of stereo-plotting equipment involved has also been found of great practical value in order to preclude errors which might seriously affect the value of the photographs for their intended use. This is done by photographing an area where a great number of elevations are known. The resultant negatives are then used to make plates for observing the flatness of the visual stereoscopic models upon which the operator works while compiling the map.

The base on which the emulsion is coated should be dimensionally stable. A highly interesting and valuable discussion of this subject was presented in Dr. Calhoun's talk[1] at the last annual meeting of the American Society of Photogrammetry. Although such statistics as are available indicate that the film base now in use has a fair degree of stability there is a general feeling among photogrammetrists that the film base now used is far from the final answer for the compilation of an accurate topographic map. The present film base being a plastic leaves much to be desired, and a reasonably dimensionally stable base will solve many of the present day problems.

To specifically define photographic quality is very difficult as each individual concerned with photography has very definite ideas concerning what constitutes a good or usable negative. This problem arising early in the history of photography was simplified by the invention of what is known as the "H and D" curve. It was named after the two Englishmen, Messrs. Hurter and Driffield, who devised the method. This method consisted of defining the relationship which existed between the amount of the silver produced by a given exposure under fixed conditions of development and the determination of its light absorbing and transmitting properties. They defined the term transparency as the ratio of the incident light to the emergent light. The opacity was defined as a reciprocal of this value and the density was defined as the logarithm of the opacity. For instance, if only 1/10 of the original amount of incident light came through the negative, the opacity would be 1/10 and the density would be 1, a logarithm of 10. If only 1/100th of the incident light came through the negative, the opacity would be 1/100th and the density would be 2, or the logarithm of 100. It is very important to understand these relationships as much of the later material presented here concerns the density of the aerial negative. By plotting the measured density caused by a known exposure and time of development, a resulting curve is produced which tells the photographic scientist many things. We are primarily interested in the effect that different densities have upon the resultant images which the operator of the stereo-plotting equipment sees when compiling his map. It follows here that the densities produced on the original negatives should be so regulated as to produce, as well as possible, an image of the earth's surface which accurately and faithfully records all of the details present at the time of exposure. It should be explained here that photographic sensitometry or the science of measuring densities produced on various photographic materials is strictly a laboratory procedure. A strip of a particular material is exposed by means of a sensitometer to very accurately measured quantities of light; it is then developed in strict accordance with scientific practice and the resulting densities are measured on an instrument called a densitometer. Now that both exposure and the density produced are known and measured, a resulting "H and D" Curve can be plotted. Curves are obtainable for all materials, both negative and positive. Therefore, it follows that the densities which are allowed to be built up on the original aerial negative should match the

[1] Calhoun, J. M., *The Physical Properties and Dimensional Stability of Safety Aerographic Film*, PHOTOGRAMMETRIC ENGINEERING, Vol. XIII, No. 2, pp. 163–221.

densities which can be built up on the positive material in order to produce the best obtainable reproduction of the original subject. The densities are measured and plotted against the relative exposures required to produce such densities. Since a given exposure will produce a certain density, these curves are relative, that is, it is assumed that a certain exposure was required for each density. It is emphasized that the exposures are only relative and that the curves differ from those which would be obtained under laboratory conditions. However, they will show the type of curve obtained by measuring different types of aerial negatives, and it can be demonstrated that a negative having an "H and D" Curve with a slope of 45 degrees, or having a gamma of 1, is the best obtainable for stereo-plotting use. This value will vary slightly with the altitude of exposure and the nature of the terrain, but will be satisfactory in most cases. Gamma is defined as the tangent of the angle formed by the straight-line portion of the curve with the base. Another photographic property which should be defined here is latitude, or the number of tones that can be reproduced on any particular photographic material. This is of particular interest to the user of stereo-plotting equipment as the greater the tonal range with sufficient differences that we can retain the more detail we can see on the final print. It follows then that gamma and latitude are inter-dependent and it is obvious that too low a gamma tends to give a monotone or cause the different images to blend into each other and conversely too high a gamma restricts the latitude so that images disappear due to the fact that there is no tonal range present to reproduce them.

Other factors which are completely controlled by the density are the printing time it requires to obtain a satisfactory reproduction; the type of photographic material which must be used; the type of developer and its relative strength. Since reproductions for stereo-plotting equipment are usually made on emulsions similar to that which is on the original aerial film, and since used as transparencies the retention of the tonal range is not as great a problem as when the reproduction is made on an emulsion on a paper surface which must be viewed by reflected light.

In using stereo-plotting equipment, if certain portions of the reproduction viewed are too light, in most cases of a density below .04, or if too dark, usually a density above 1.5, the operator finds that he experiences great difficulty in making accurate measurements, or parallax readings, for elevations. Since the reading of elevations, or the drawing of contours and planimetry is the basic use of stereo-plotting equipment, it is elementary that the aerial negative should not produce densities which will be higher or lower than the above mentioned densities during the average exposure time required to print the reproduction which the operator views. In other words, the brightness range of the photographed terrain should be reproduced on the original aerial negative so that when the glass transparency to be used in the stereo-plotting equipment is printed, none of the information will be beyond the power of the operator to measure accurately. By way of further explanation, if snow and shadows exist at the time of exposure a negative with the above-mentioned characteristics can be produced by utilizing the proper emulsion, filter, exposure time and by proper processing. It is admittedly difficult, but possible. Conversely, in certain parts of the country such as desert wasteland, the proper emulsion, filter and processing will enhance the contrast of the original subject so that the above-mentioned densities will not be exceeded. The result is a much better reproduction on which the operator can make the required measurements.

Since certain densities and a gamma have been recommended, it is in order

at this point to ascertain what effect these factors will have upon the graininess and the sharpness and resolution.

The term "Graininess" is applied to the degree of non-homogeneity visible at low magnification—as in projection or projection printing—to distinguish it from the non-homogeneity produced by the separation or resolution of the individual silver grains which is possible at much higher magnification. While the two are related, graininess is of concern to the user of the stereo-plotting equipment, since it tends to weaken the resolution and apparent sharpness. The graininess of any particular negative is primarily dependent upon the grain size inherent in the original emulsion, but the methods and materials used.in development have a great effect on the final results. A negative of low density will show more apparent graininess than one of a high density, if the resulting densities were the result of under exposure and over development. Therefore, if the negative is given the proper exposure and development in the proper developer to a low gamma or close to that which has been specified, the grain size will be at a minimum. For instruments such as the multiplex where the original negative is greatly reduced, grain does not present as great a problem as where contact reproductions are to be made and the resulting image magnified. Since it is an established fact that sharpness and resolving power increase to a certain extent with the contrast, or gamma, to which the negative is developed, the highest gamma consistent with a usable reproduction has been specified.

It is the opinion of the writer that too little emphasis has been placed in the past on the acquisition of good aerial photographic negatives. This negative is the foundation of the science of Photogrammetry and yet it is a fact that there is available a vast amount of photographic knowledge that has not been applied to obtain the best possible results in aerial photography. In no other line of photography, commercial or private, is less use made of the various materials available or the accessories that have been devised for the production of the desired negative. All other types of negatives are usually viewed once or twice and stored for reference purposes whereas much time and money is spent to evaluate and transfer the information on each aerial negative to a map and they are used constantly by other agencies and individuals other than the person who acquired them. The present practice is to use, almost exclusively, one type of emulsion and one type of filter under all conditions whether it be winter or summer or whether the terrain consists of heavily wooded areas or barren desert. In any other line of photographic endeavor, all types of filters and all types of emulsions are utilized in order to secure the ultimate in rendition of the brightness range and the spectral characteristics. A recent example of the value of a different emulsion and filter is the use of the infra-red emulsion with a minus-blue filter in certain parts of the United States where the presence of haze tends to obscure small details. This method also accentuated streams and small bodies of water which, on regular panchromatic film were hardly distinguishable. In the matter of exposure there are many accessories available which would lift the burden from the individual photographer as to just what stop-opening and shutter speed to use. Information gained from the use of any of these instruments could be utilized in the development of the film since, if the exposure were accurately known, the required densities and gammas could be produced. It should be stated here that this is no reflection on any individual or concern, but is a plea for better methods in securing the aerial photographic negatives. There are so many variables in this business of securing aerial photographic negatives that every possible step should be taken to eliminate the known factors causing errors so that the unknown errors could be reduced and isolated for study and solution of the problem presented.

The negatives for use with stereo-plotting equipment calls for high precision and excellent photographic quality if a map equal to their capabilities is to be produced, but it is the opinion of leading photogrammetrists in the United States and various foreign countries that the present film base does not meet the precision requirements to fully utilize the possible accuracy of the stereo-plotting equipment and that much can be done to improve the over-all photographic quality.

PRESIDENT MASSIE: Thank you, Mr. Harmon, for your very informative paper. I think you have thrown a challenge or two to the people concerned with securing better materials with which to make our topographic maps.

Our next speaker, Mr. Henry, is a graduate of the University of Kansas. Immediately after graduation, he went into private contracting. While at the University, he was a second lieutenant in the infantry of the United States Army, and in July of 1942 he was called for active duty. He served in the capacity of a technical officer in the Sixth Photo Compilation Squadron at Peterson Field. While there he experimented with the idea of finding the nadir point of a photograph by the use of a bombsight. Tests led to the development of a method of checking the accuracy of the bombsight gyros. This project resulted in the assignment of Mr. Henry to Wright Field, Dayton, Ohio.

In the spring of 1945, he was appointed Chief of the Aerial Photogrammetry Unit, Mapping and Charting Branch, Photographic Laboratory, and as Shoran Project Engineer.

In his paper, "Value and Application of Research in Photogrammetry," he points out that this is a broad field and has as its objective in all research "More Precise Maps and Charts."

It is with much pleasure that I introduce to you at this time Mr. Henry.

MR. JAMES E. HENRY: Mr. President, Members of the American Society of Photogrammetry and Guests: What is Photogrammetry? Photogrammetry may be defined as the "art of making precise measurements on aerial photographs." Others may define photogrammetry in such a way as to include the aerial camera and the developing and processing of film and prints. Still others may define it in such a way that it makes the field of Photogrammetry very broad.

What is Research in Photogrammetry? Is it limited to research in the art of making precise measurements on aerial photographs? As we see research in photogrammetry, it includes not only the art of making precise measurements on aerial photographs but monitoring and designing all equipment that has to do with making a precise map or chart. For example, we are conducting research in the following: applying electronics to mapping, charting, and reconnaissance; developing negative lettering stamps; methods and techniques of using radio altimeters, stabilized mounts, flight line navigation aids, wide angle viewfinders; comparative tests of various focal length cameras at the higher altitudes (40,000 feet and above); precision mapping cameras; moving film principle; geodetic studies such as daylight star photography; plotting and sketching instruments; reproduction methods and techniques; and various other projects that pertain to mapping and charting.

What value is received from Research in Photogrammetry? Generally speaking, from our viewpoint, this could be summed up into a few words. "More Precise Maps and Charts." Every wise manufacturer, regardless of what he builds, whether it is airplanes or safety pins, has a research department so that he will be continually improving the item which he manufactures. Therefore, if photogrammetry of tomorrow is to be abreast of other allied corresponding developments, we must maintain and encourage continuous research in Photogrammetry. In order to give a more comprehensive idea of what the Air Force is