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

doing in Research in Photogrammetry, a number of projects will be discussed separately.

1. *Radio Altitude.* Vertical control has been a problem to the photogrammetrist for many years. The SCR 718 radio altimeter, an electronic device which gives the altitude of the plane above terrain, was developed in the early days of World War II. The possibility of establishing vertical control with this device has been thoroughly tested and it has been found to be unsatisfactory for mapping. The device has a 70 degree beam width and the return signal may be from a mountain several thousand feet ahead of the aircraft. Since the beam width was undesirable, a new narrow beam radio altimeter with a beam width of 1.3 degrees is under development. The tests conducted to date on this new altimeter look very encouraging; and within the next six months, tests will be conducted and data will be compiled to determine if a combination of barometric and radio altimeters may be satisfactory for establishing vertical control in mapping and charting. If methods and techniques can be developed so that vertical control may be established simultaneously with the taking of photographs, its value cannot be estimated in terms of dollars and cents; and its application will be wide in the field of mapping and charting.

2. *Barometric Altitude.* A reliable corporation is under contract to deliver a variometer which they guarantee will indicate deviations from a constant barometric altitude within the limits of a plus or minus five feet. This will not only be valuable in obtaining vertical control, but will give relative elevations between exposures which may be a very important factor in determining the tilt of an aerial photograph without ground control.

3. *Stabilization.* For the past few years, the Photographic Laboratory, Engineering Division, has been conducting tests on various stabilized aerial camera mounts. We are proud to announce that flight tests conducted in December 1947, indicate that one type mount is holding the camera within plus or minus 15 minutes of a level position. This is indeed very promising since we know we will be able to improve the accuracy as soon as a new gyro can be procured which is definitely superior to the gyros that are presently being used. However, it must be remembered that, regardless of how accurate the gyros are which indirectly control the mount, the first requirement for a stabilized mount to function properly is that a photogrammetric flight line must be flown. A photogrammetric flight line is one that is flown straight and level. Accelerations for short periods of time do not affect the gyros; but if an airplane loses altitude for a period of five minutes with a constant power setting, then an acceleration has existed for five minutes, the result being an error in the stabilized mount due to the precession of the gyro. The problem of stabilization has been one which has given engineers many headaches; but we feel sure that within a few months, stabilized aerial camera mounts may be procured which will meet the requirements of the mapping, charting and reconnaissance agencies. Many hours of research have been spent by the Air Force and other agencies developing various stabilized mounts, and again its value to mapping and charting cannot be measured in mercenary terms.

4. *Shoran Mapping.* The application of Shoran to mapping and charting has been a research project that has been of prime importance. It has required many hours of research with various organizations completing different phases. The 7th Geodetic Control Squadron, 311th Photo Wing under the direction of Colonel Carl I. Aslakson has conducted valuable research in line measurements with Shoran. In their recent reports, they disclosed that a high second order

accuracy was obtained in their latest tests. Various tests on high precision Shoran equipment will be conducted during the next year, and it is hoped that first order accuracy will be obtained in line measurements and a high second order accuracy may be obtained in mapping photography on each individual photograph.

5. *Straight Line Indicators.* Various devices have been developed for flying straight and parallel flight lines and the most promising one is the Shoran Straight Line Indicator. However, this instrument is only good when used with Shoran equipment. Photographic flight lines 375 miles long have been flown with this instrument and the standard 30% sidelap was obtained with no gaps in the photography. A Shoran intervalometer is being designed as a component part of the Straight Line Indicator which will operate independently of time and speed. The main feature of this item will be that all of the photographs in each flight line will be exactly opposite the photographs in all succeeding flight lines. This intervalometer should save many hours in compilation since the time required to pick pass points should be greatly reduced. The Indicator is now being modified to work in conjunction with the automatic pilot. If this modification works as it should, the pilot should be able to read a detective story while flying a photogrammetric flight line.

Fifty-four Straight Line Indicators are being procured by the United States Air Force. They are designed so that a 1:1,000,000 scale chart may be oriented on the base plate in such a manner that the intersection of the threaded arms will always indicate the position of the plane with respect to the Shoran ground stations. Again, this is the result of continuous research.

6. *Moving Film.* The moving film principle is one of controversy to the photogrammetrist. It was first believed to be valuable only to reconnaissance. However, in the past few years, the speed of aircraft has approached the speed of sound, and motion of the image during the exposure is becoming more and more a problem to the photogrammetrist. After a comparison of a pair of photographs has been made, under the stereoscope, exposed with the moving film principle and a pair without, one is easily convinced that the moving film principle is important in the field of photogrammetry. The focal plane shutter has never been considered satisfactory for mapping; but if the moving film principle is employed in the design of future mapping cameras, then it will be possible to make use of this type shutter. For example, Figure 1 is a photograph of an airplane traveling at a speed of 1000 m.p.h. with respect to the airplane from which the photograph was exposed. With the airplanes flying at a speed of 500 m.p.h. passing each other in opposite directions, a relative speed of 1000 m.p.h. was obtained.

7. *Viewfinders.* A satisfactory viewfinder for the photographer and pilot has been a problem to the Photographic Laboratory. A contract was awarded to a reliable corporation in 1946, to develop a viewfinder that would produce a brilliant unreversed image and have a coverage equal to our present six-inch focal length mapping cameras. The first model was delivered in July 1947; and when the first mission was flown, the photographer suggested the use of a filter to cut down the brightness of the image. The development has progressed rapidly. We now have a viewfinder nearing completion that has a coverage of 110 degrees and requires only a $1\frac{1}{2}$ inch hole in the skin of the aircraft. The image of this viewfinder is being piped to the pilot's instrument panel so that it may also be used for a flight line navigation aid.

It is also interesting to note that photographs have been made with a combi-

nation of lenses employing the aspheric lens and the designer can see no reason why a 180-degree coverage cannot be obtained.

8. *Daylight Star Photography.* Another project of special interest is daylight star photography. The Ohio State Research Foundation under contract to the Air Force has been working on this project for almost one year, and they have recently been able to photograph a fourth magnitude star at 9 o'clock in the morning. Two types of cameras have been used on this project, a 12-inch focal length and a 60-inch focal length. No positive results were obtained when daylight photography of stars was attempted on many occasions with the 12-inch

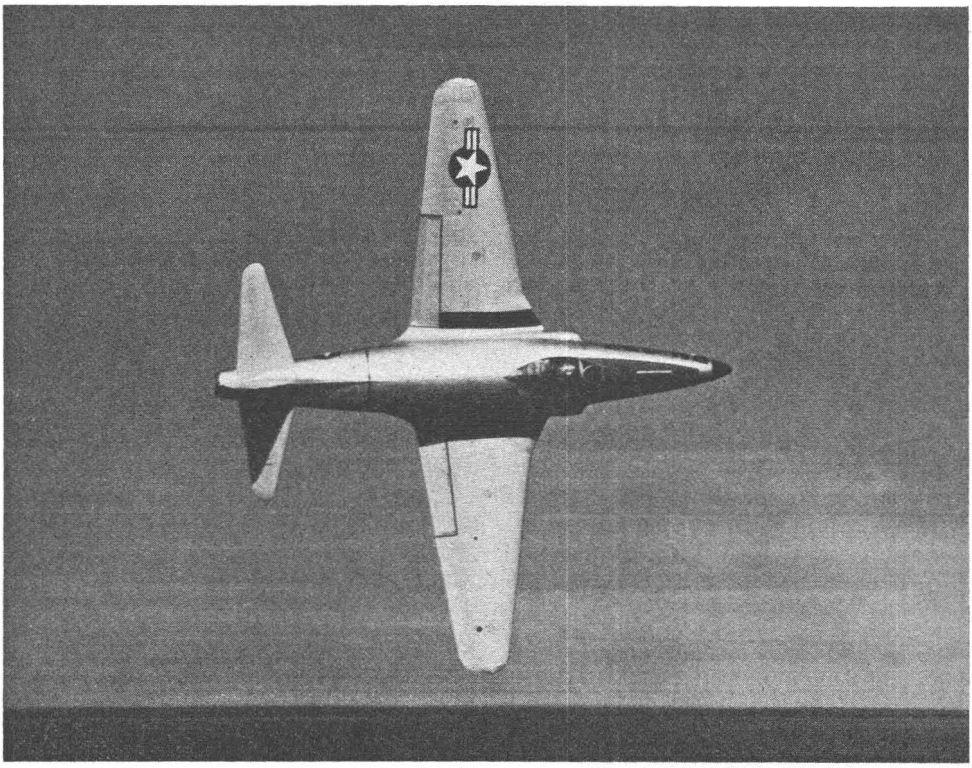

FIG. 1. P-80 traveling 500 m.p.h. photographed with moving film camera from another plane moving 500 m.p.h. in opposite direction. Relative speed 1000 m.p.h.

focal length camera, but amazing results were obtained with the 60-inch focal length camera. The difference in results obtained between the long and short focal length cameras is very significant, but somewhat difficult to understand. From the results of this research, to date, it appears that astronomic control may be located in daylight or darkness. These are a few of the projects on which the Air Force is working that have a direct bearing on the photogrammetry of tomorrow. Their value and application cannot be over emphasized.

Every organization that is working in photogrammetry should encourage their employees to present new ideas. If these ideas could be presented to a committee on research in the American Society of Photogrammetry for evaluation; and if this Society at their annual meetings would give recognition for meritorous accomplishment to those persons who are not working directly in research, it would be another step forward in encouraging research in photogrammetry.

PRESIDENT MASSIE: We got off to a late start, and wish to save as much time as we can, but if there are any questions you want to ask Mr. Henry we can spend a few minutes with them.

MR. EDWARD H. CAHILL: I would like Mr. Henry to explain the method of determining the angle of tilt of the camera by his barometric method.

MR. HENRY: I was just a little afraid somebody might ask that, and for that one reason I mentioned it very briefly. However, we would have to go into great detail and it would require a blackboard to discuss it. It has not progressed far enough to give any definite conclusion. If you will notice, I said it might be a very important factor. I am convinced myself, but it has not been proven yet.

MR. J. A. KOWALSKI (U.S.N. Photo Interpretation Center): I would like to ask what hopes there are in this daylight star photography with twelve-inch focal length lens.

MR. HENRY: With the twelve-inch focal length lens our results have been very poor. However, with the sixty-inch focal length we have been able to obtain amazing results.

PRESIDENT MASSIE: Thank you, Mr. Henry. As was stated last night, we have to depend on such organizations as the one you represent to actually finance and perform the research. The Society will be delighted to receive any information it can and will be glad to disseminate the information, if we are permitted to do so.

Mr. Henry has been talking about research in photogrammetry. I have learned of a project which is being carried on by the Coast and Geodetic Survey, and while our time is limited, I understand that it is of sufficient importance that we would do well to devote a little time to this subject. I will appreciate it if Commander Reading will tell us about this project.

COMMANDER READING: After listening to the rather tremendous research that is going on at Wright Field, I feel hesitant about taking a couple of minutes to tell you of this little project of ours in the Coast and Geodetic Survey.

When I first started studying photogrammetry, I read that lenses have symmetrical distortion and that the film shrinkage is quite uniform, although the papers shrink more in one dimension than another, and that plotting machines can be set so as to clear parallaxes, and such things as that.

When we actually began using this against geodetic control, we found that we needed to improve the accuracy and redefine our tolerances, so to speak. As all engineers were, we were interested in the final results that we could get from the equipment, the precision of the total process.

Many years ago we used test areas to determine the accuracy of our ground methods compared with the photogrammetric process, and were usually content to locate places on the ground and reference them in later on measurements of the photographs that had been taken without any ground marking.

To expedite the development of the nine lens plotting equipment, we concluded that a test area having stations that could be marked and targeted would be highly desirable and that this test area should be readily accessible on the ground so that the first targets could be put out quickly and easily, and it was highly desirable that it be quite flat so that it could be determined whether our film was shrinking locally instead of generally. We wanted to know about that as well as our optical setup.

For these reasons an area about thirty-five miles southwest of Toledo was selected for a special test area. It is five miles square and contains some eighteen monumented points in the twenty-five square miles. It is flat sectionized country with hard-paved roads running past the monumented stations, and there are

few woods, so practically the whole area is accessible to easy stereoscopic observations.

The maximum difference in elevation, I think, is within ten feet, and there are two-foot contours throughout the area. One can contour the roads, if desired, within a few inches.

The marks themselves have been determined by triangulation within one decimeter and have levels so that the position is correct without any traverse adjustment within that decimeter.

The data for the survey have not yet been received from the field. It will probably be two or three months before they are available, but if any of you would like to use them, I am sure the Coast and Geodetic Survey would be glad to make them available.

PRESIDENT MASSIE: Thank you very much, Commander Reading. I have a hunch that you will be called upon for some of that material.

Our next speaker, Mr. Podeyn, obtained his education at Lehigh and New York Universities. For the past five years of his association with Fairchild Camera and Instrument Corporation he has specialized in aerial photographic and photogrammetric equipment. He has been working especially with the phases of the work connected with radar.

Mr. Podeyn is the author of several articles dealing with radar charting. At present he is Manager of the Commercial Aviation Equipment Division of Fairchild Camera and Instrument Corporation. His paper, "Radar Charting, a New Application of Photogrammetry," deals with one of the newest and most exciting developments in mapping of the recent years. Mr. Podeyn.

MR. PODEYN: During the war, radar was born and grew to be a lusty youngster before many of us had heard of it. Such security was essential, of course but it has resulted in our having only begun to make non-military use of this electronic tool very recently.

There were only vague conjectures as to the peacetime usefulness of radar photography because the first job was to produce training photos. Bombardiers and operators first grew to know radar from photos made with cameras stuck on "stove-pipes" which were mounted on the oscilloscopes. Many ingenious methods were used to keep records of the images presented on the radar scope. Most of these were devised by field personnel who used what was at hand to solve the problem. As a preliminary effort to supply a complete recording system, we worked with radiation laboratory in production engineering and produced a quantity of what was then known as the Bolex Coffin. This unit was suggested by personnel of the 8th Air Force and was a fancy modification of a standard movie camera which was mounted in one end of a light tight box. A slave scope, clock and other data was grouped at the opposite end of the box. All of this information was automatically recorded.

Although the coffin was capable of producing very good radar photographs, it was large, awkward to use and in general just a very clever field unit. To obtain improved equipment, several independent efforts were being made to design the ideal radar camera. Security prevented complete liaison and kept these efforts individual for a time but the prototype of present Fairchild radar cameras was examined and interested Army and Navy personnel.

The Army, Navy and radiation laboratory joined together to make a "crash" project of the production of this camera which has been the standard radar camera with the Army and Navy since that time. Since the end of the war, this camera system has been refined and adapted for many radar, oscilloscope, and instrument recording jobs and also for conventional aerial photographic uses on magnetometer surveys.