lematical. Some method of stabilization must be maintained through the missile flight and attitude changes to obtain satisfactory photographs.

Camera installations in vertical take-off (VTOL) airplanes present similar problems in that the airplane starts and hovers in a vertical position, and during flight assumes a level position. This requires a stabilized camera installation capable of taking accurate pictures while in horizontal flight, or while the airplane is hovering in vertical flight.

High-speed flight introduces additional problems brought about by aerodynamic heating. This causes deterioration of materials, as well as distortion and deflection of camera windows and mounts, due to expansion and contraction. The final accuracy of the photographs is reduced. The effects of heating are somewhat alleviated by air conditioning the camera compartment, a single-place fighter-reconnaissance airplane requiring refrigeration equal to that for a modern railroad refrigerator car.

Another problem presented by high speed airplanes is the result of high speed maneuvering. This, of course, increases the "*g*" load on the camera and mount, and to some extent curtails the camera field of view and again the accuracy. The need for high maneuverability is realized when it is considered that reconnaissance airplanes will be subjected to more intensive attack in the future than in the past. Heretofore, a single airplane was considered to be a reconnaissance airplane, and was only subjected to local interceptor action. Since Hiroshima, it has been recognized that any airplane could be carrying a nuclear weapon and, therefore, it will receive as much interception as an entire squadron.

To complete a mission the reconnaissance airplane must get to the target and return to base. After a bomber has dropped its bomb on the target and the interceptor has downed its target, their missions have been accomplished. In neither case does the fact that they are shot down afterward abort their missions. On the other hand, the reconnaissance airplane, to complete its mission, must return to its base, or pass the information it has collected on to the intelligence centers.

To avoid enemy action, the high speed reconnaissance airplane will be subjected to maneuvers putting exceedingly high "*g*" loads upon the airplane and camera installations. Camera mounts that can maintain stability in all attitudes are needed to permit accurate stabilized photography while the airplane is subjected to evasive action maneuvers.

Hypersonic speeds impose even greater problems in camera installations due to speed and altitudes. Present day cameras carry image motion compensation. However, present days speeds are far less than the ultimate speeds which are predicted for five or six years from now; the problems of accelerating the film and camera mechanisms to take care of ground speeds will then be more difficult. Aerodynamic heating of camera windows as well as adjacent structure may require new materials and processes.

Ex-Temporaneous Statement by Mr. Eldon Sewell

Engineer Research and Development Laboratories

MR. PALLME has asked how much value in photogrammetric work is improvement in the resolution. Everyone wants high resolution. We all have the problem of seeing what is on the ground. Mapping requirements for resolution differ very little, if any, from those of the photo interpreter. The photogrammetric mapper really is a photo interpreter. His method of presenting the interpreted data may be different and he may be interested in different kinds of data, but he fulfills all the requirements for a photo interpreter.

I will say a few words about vertical stabilization, to distinguish it from steadying. Even though the original purpose for gyro controlled mounts was vertical stability, it seems quite probable that their greatest use will be for improving resolution through steadying the camera. However, the Air Force has not forgotten the requirement for vertical stability and is continuing its quest for a satisfactory solution.

Every photogrammetrist dreams of some day having truly vertical photographs. In learning to be a photogrammetrist, Chapter 1 of the photogrammetry test gives to a student instruction on vertical photographs, and their similar triangles and simple ratios. He thinks that photogrammetry is a cinch. But then he turns to Chapter 2 which starts out "Since we never have truly vertical photographs we must learn to deal with tilted ones. To learn how, study the rest of this book, plus Volumes 2, 3 and 4."

The original tilt requirement from the Corps of Engineers was for tilts not exceeding $3\frac{1}{2}$ minutes about each axis, making a resultant tilt of about 5 minutes. Five minutes is so near one-tenth of a degree that someone started using one-tenth of a degree, or six minutes, as a criterion. Later this drifted to six minutes about each axis, or a resultant of $8\frac{1}{2}$ minutes. Maybe after this is achieved the original requirement will be reviewed.

The original tilt requirements earlier mentioned would have been useful in setting up the multiplex in areas where control is sparse. However, with modern plotting instruments, like the Kelsh plotter and some foreign instruments, and with higher altitude photography, three minutes of tilt is excessive. Tests to determine how much tilt can be tolerated have not been completed but it seems to be more in the order of one minute. Even with one-minute tilts, there probably would be residuals in our parallaxes which could be recognized and which we would want to remove. Since we wouldn't know which projector to tilt, we might make matters worse instead of better.

I do not want to leave the impression that photos stabilized to $3\frac{1}{2}$ minutes or even five minutes would not be extremely valuable in photogrammetric work. One very important use for such photography is in locating the nadir point of shoran controlled photography. The position of the aircraft can be accurately determined from shoran measurements, but a large error may arise in locating the point on the ground directly beneath the aircraft, especially in uncontrolled areas.

Another very obvious and useful application of stabilized photography is for controlled or semi-controlled mosaics. For such mosaics we now analyze each photo and rectify those having excessive tilts. With tilts under five minutes, we could eliminate this time-consuming and expensive operation. Accuracies of slotted templet assemblies also could be improved with photography having low tilts. There are many applications, other than map compilation, for which low-tilt photographs are superior to those having up to, say, three degrees tilt, which much unstabilized photography has.

Efforts to improve the verticality of the stabilized mounts are being made by the Air Force and Aeroflex Laboratories. Flight tests show that improvements are being accomplished although the problems become more acute as the vertical is approached.

Questions and General Discussion

MR. LEWIS (Pacific Air Industries): In his talk Mr. Beck didn't say whether in his opinion there is much difference in the installation of a camera mount in the jet aircraft as opposed to the conventional type. I don't believe any commercial photogrammetrist today has jet aircraft in the air. However, Mr. Alter covered the question so thoroughly he has me greatly disturbed.

MR. ALTER: Yesterday I questioned one of the lecturers on the advantages he got out of speed. He said that he really didn't need the speed but instead he was looking at the altitude he got out of a jet aircraft. I don't believe speed is of any advantage. In fact, it is a distinct disadvantage. Altitude reduces the cost of photography tremendously, but I think that the problems you run into with a jet aircraft just to get altitude would be many times the problems you have at the present moment.

MR. BECK: From what we have been able to learn in discussion with our vibration and flutter men, we anticipate much less trouble from airplane vibrations on the stabilized mount and expect a lot better resolution of the camera on jet installations.