MR. ABRAMS: In my original remarks I made the statement that about 90 per cent of the people who were using aerial photographs, who make maps, or who inspect them or interpret them never went to school to study that subject, and I think that is just about right. I know that 90 per cent of the people is a great majority of the number interested in this profession. Only 10 per cent will probably ever have formal training.

There have been trained in the United States, in colleges and universities, a few hundred people who have made a specialty of studying the subject of photogrammetry in its entirety, but here is the other 90 per cent who have not had that opportunity. Something has to be done to help them. For example, our company has opened several schools around the country in an effort to do that. We went into areas like Mississippi, and in cooperation with the Mississippi Highway Department we opened a school.

We let them invite in the highway engineers, principally, and the locating engineers from the adjoining states. The state highway department would sponsor that meeting. We would, in a period of one week, show them what aerial photography was, how to study it stereoscopically and how to make several kinds of maps from those photographs.

That is really very elementary and we know it, but, for example, here is a group of graduate engineers. Probably the majority of them are civil engineers, and we must train them so that they can go back to their jobs. They cannot be spared for more than a week or so, and we try to give the training in that period of time. More schools of that kind all over the country and around the world would help out this program. Does that answer your question, Mr. Tewinkel?

MR. TEWINKEL: I think it does. Thank you very much.

Our time has drawn to a close. I know we have not covered the subject completely, and there are many good ideas from the floor. It is suggested that if you wish—and we encourage you to do so—to write these ideas and submit them to the Society and they will be incorporated in the published proceedings of this meeting along with those that have been submitted from the floor.

Perhaps we might conclude from these remarks a number of things, among them, of course, is that we recognize the lack of education, and we have seen that there are at least three different approaches to the problem of training in photogrammetry, none of which has been thoroughly taken up or accomplished so far. With that, the panel is closed.

PRESIDENT MASSIE: Mr. Tewinkel, I would like to thank you for the able handling of the panel this morning. Our next speaker, Mr. V. R. Short, has been connected with the museum at Yale and also the museum in New York City. He is now connected with the Sikorsky Aircraft Division of the United Aircraft Corporation and has been for some time. It is with great pleasure that I present to you Mr. Short who will talk on "Sikorsky Helicopters—the Flying Tripods."

MR. SHORT: In this article we point out the various problems involved in using the helicopter as a flying tripod and illustrate some of the preliminary results with the hope that the specialists in the various phases of photogrammetry will carry on from here and show us what a fine job can be done. As most of you know, a successful practical helicopter is scarcely eight years old and through the acceleration of the war effort, the Sikorsky type has amassed some sixty thousand hours of flight experience devoted mostly to rescue, reconnaissance and other military uses. As the commercial types were first released from the production lines early in 1946, even our engineers and sales department could not have dreamed up the inexhaustible list of suggested uses and ideas that poured into our edifice for various uses of the helicopter. One of the frequent inquiries was in connection with the use of the helicopter for various types of

photography and survey work. Early experimental work sandwiched in between war-time deliveries of helicopters was rather discouraging. There appeared to be objectionable vibrations and oscillations of the fuselage which made still photography difficult and movie photography downright horrible to behold. As experience in manufacturing developed and we found out more and more about this new vehicle that we had produced, our engineers were able to analyze and later totally eliminate the objectionable features of the helicopter for aerial photography. All of the vibrations which were hampering us in our work were of a relatively slow rate of vibration and of a fairly high displacement.

FIG. 1. R-4 Army Sikorsky Helicopter.

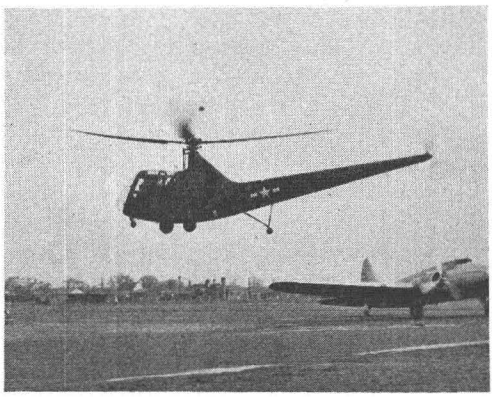

FIG. 2. Army Sikorsky R-6 Helicopter.

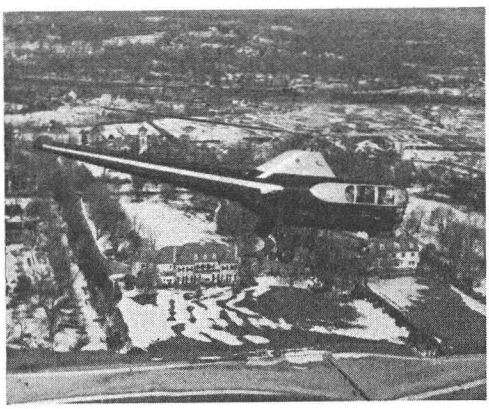

FIG. 3. Sikorsky Commercial S-51 four-place Helicopter.

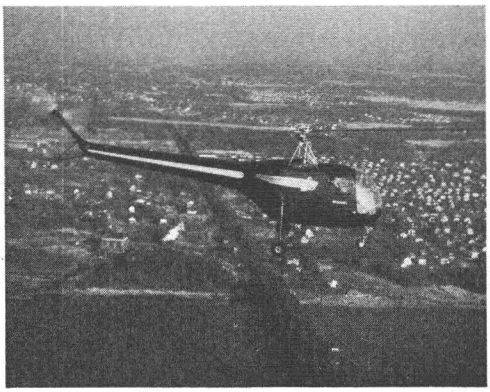

FIG. 4. Sikorsky commercial S-52 two-place Helicopter.

During this early stage of our experiments a pronounced one-per-revolution vibration caused by one of the rotor blades being out of track was our most troublesome phenomenon. As we went into production on the Sikorsky R-4 and R-6's and better blades with improved characteristics and methods of tracking were developed, this phenomenon disappeared and today in our present commercial type helicopters such as the S-51 and S-52 this condition is never encountered with proper maintenance of the aircraft.

In the Sikorsky type, which at the present time has a single main lifting rotor

with three blades, there is a slight three-per-revolution vibration. The magnitude of this vibration is fairly low and the displacement is apparent but not uncomfortable to the passengers or in any way objectionable for photographic purposes except where it coincides with shutter speeds of the camera. I might call your attention to the fact that the number of times that this vibration occurs in any helicopter built at the present time will be equal to the number of blades in the main rotors, per revolution. It is an aerodynamic condition and it becomes apparent at once that a single or two-bladed main rotor would be more objectionable in this respect than a helicopter with three or more blades which tend to smooth out or cancel this effect. In the various Sikorsky types that have been built to date you will see illustrated in Figure 5 the RPM of the main rotor of each type in column one. In the second column, the reciprocal of the three-per-revolution condition is indicated and you will see at once that by operating a still camera at shutter speeds of from 1/250 to 1/400 of a second no difficulties will occur. Of course, in single exposures such as oblique shots, there is less danger of shutter operation occurring precisely at the time and in sympathy with the vibrations as there might be during a mapping run. Using this same chart as a guide, you will see that for motion picture cameras, sixteen frames per second unfortunately lies right in the middle of the dangerous range near the reciprocal point .062, whereas at twenty-four frames with .041, or better still, thirty-two frames at .031, no difficulty would be encountered. Today practically all moving pictures because of sound track are taken at twenty-four frames where little or no problems have been encountered.

Sikorsky Helicopters

Model	Main Rotor r.p.m.	3 Per Rev.
R-4	230	.087
R-5	190	.105
R-6	290	.069
S-51	190	.105
S-52	290	.069
Movie Cameras		
16 Frames		.062
24 Frames		.041
32 Frames		.031

FIG. 5. Exposure data.

The helicopter, being a universal type of short-haul transportation, has not been built specifically to fill the bill for aerial photography. It has been considered too costly and rather difficult to build special wells in standard ships for cameras or to design a helicopter specifically for any one limited use. In the beginning, all of our experimental work was done with hand-held cameras such as the Speed Graphic. Later using a K-25 as a pilot model, we developed a bracket that can be used outside the aircraft for support of the camera in its proper stable position and still be convenient for operation in mapping, etc.

A light aluminum bracket clamping on the door sill and side frame supports the camera from a single shock mount connected with a bracket bent in such a manner as to hang the camera over its normal c.g. and with prism at right angles to the floor or ground. An adjustable flag or sail is mounted above the shock mount and adjusted for the speed to which the helicopter is operating. Thus the air pressure on the sail equal to the air pressure on the camera cancels out

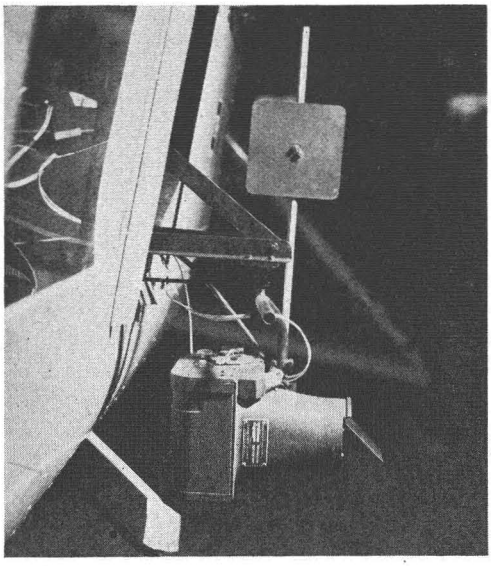

FIG. 6. K-25 camera with bracket showing installation on door sill of S-51.

any tendency for swinging. A rod fixed to the camera mounting and carried to the bracket prevents turning in azimuth or weather cocking of the camera. Of course, in larger installations where gimbal mounting is available the bracket would be required only to support the master gimbal ring and suitable sail area to cancel out movement because of air pressure.

With the use of this type of installation no modification of the aircraft is required and a cord with an operating switch is plugged directly into the twenty-four volt dome light in the cabin converting the aircraft in a matter of moments from passenger carrying to an aerial reconnaissance vehicle. This same installation modified slightly could be used for much larger equipment. Due to the fact that there are no slip stream problems from propellers and that the helicopter operates at relatively slow flying speeds the external mounting of the camera appears to present no technical problems.

We realize it would be uneconomical to use the helicopter for large area surveying and mapping. It is my understanding that there are probably only a few days in each year, at least in our section of the country, when it is possible to cover general mapping from high altitudes because of weather conditions. With a helicopter, it is possible to supplement the over-all picture with detailed information taken at relatively low altitudes, that is, not exceeding five thousand feet on days not suitable for high altitude work and to obtain more accurate samples or pinpoint dimensions for specific areas.

Extremely accurate one-foot contours may possibly be obtained in survey work at low altitudes where violent geological upheavals make accurate information difficult. This probably will prove to be true in the study of soil erosion by photography.

It has been suggested to us and experimental flights have been made to determine, for example, the number per acre of hardwoods mixed in with conifers in timber stands. A census of a large area can be taken quite accurately by normal stereo high altitude photographs, as far as number of trees is concerned. Individual identification is quite difficult to get from higher altitudes.

With the helicopter it is possible with the proper use of filters and types of film to accurately estimate proportions of various types of growth in the sample areas and in many cases individual species may be identified. Fig. 7 shows the result of a normal mapping run at fifty MPH at an altitude of three thousand feet. It was taken with the K-25 installation described above, with standard panchromatic film and a minus blue filter. It is not intended to be an expert example of aerial photography but is merely to demonstrate the approximate coverage at the various altitudes and the amount of detail shown. I believe that the slower speed of the helicopter and its prompt response to directional control will prove to be a valuable aid in recording details of our forest growth and distribution and extremely valuable in studying progress of forest diseases.

FIG. 7. Mapping run at 3000 feet 1/125 of a second—minus blue—45 MPH—3 prism.

While we do not at the present time have photographic records, I have personally hovered one hundred feet off from the face of the Palisades and studied geological formations that would otherwise be impossible to see close up or to record for study without building expensive and complicated scaffolding.

Figures 8 through 10 are not particularly unusual and some of them, such as the obliques, could possibly have been taken from conventional aircraft, but I doubt it. To come in over a reasonably congested area and pick up details such as the name on the garage and the slogan on the billboard would be extremely hazardous in any type of fixed wing aircraft.

Here we have an unusual tripod that can be extended from five feet off the ground to thousands of feet in height. It can be moved one, five, five hundred feet or a mile in any direction nearly as quickly as the photographer can think of the move. We can slip in behind the powerhouse and photograph the facility from one hundred feet over a canal or we can hover motionles over the top of a smokestack and determine whether the top needs repairing as easily and as quickly as we can handle our Speed Graphic on the ground.

The use of the helicopter for the taking of motion pictures has been used by our organization for study and records for some time. Commercial uses of this type of aircraft as a flexible movie tripod is only just beginning to be explored. The early photographs taken from an R-4 landing on board a British motor ship during test military operations give an example of the early oscillations of the aircraft that was considered undesirable. While flying over the new Mexican volcano Paricutin in a U. S. Army R-6 and photographing directly into the mouth of the volcano, it was noted that in spite of the extreme rough air, we were able to attain some very interesting scientific and spectacular results. One of the first attempts to make commercial use of the helicopter as a tripod for motion picture photography was made at Rockingham Park where first dry

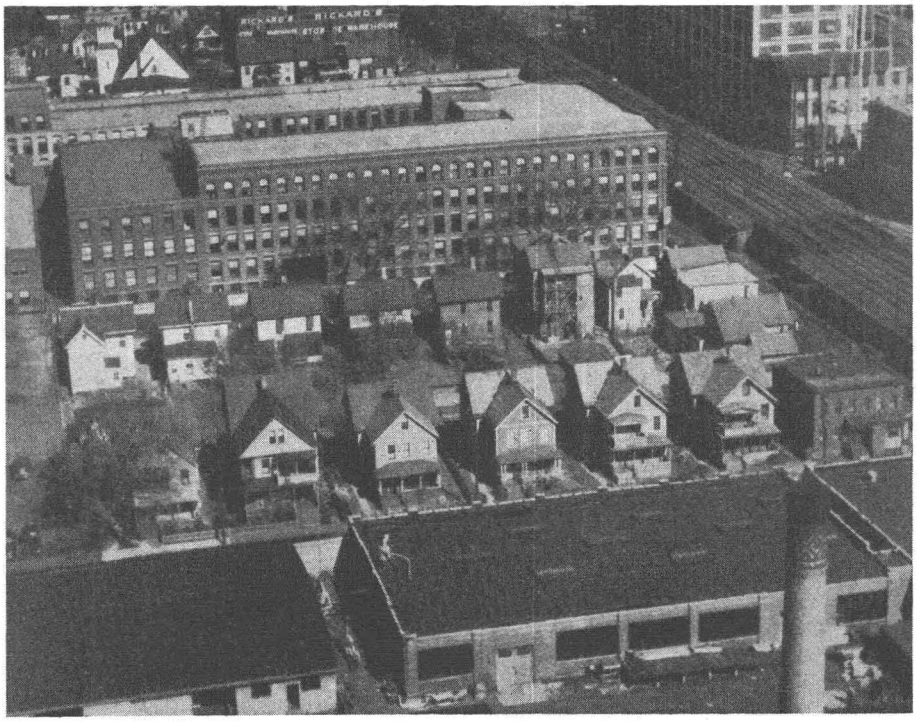

FIG. 8. 400 foot altitude in vicinity of chimney and other camera obstructions 1/250 of a second—minus blue—30 MPH.

runs and then during the actual time of the running of the races the helicopter was used to monitor the conduct of the jockies and horses. We were told by judges at the track that the meet held with the helicopter as an aerial observation post was the cleanest they had ever witnessed as far as crowding and other iolations hard to observe from static conditions was concerned. It is my understanding that fairly successful results were obtained by one of the production companies on the West Coast, with the use of a two-place helicopter; because of the size of the equipment it was necessary in this case to mount the camera partially inside and partially outside the fuselage.

We have installed a professional Mitchell and also a Technicolor camera in our S-51 and made some extremely successful pictures. Professional movie photographers seem to appreciate the roomy S-51 as they can keep all the equipment inside the cabin with necessary room for panning and other movements of the camera. According to my agreement, we have about five minutes for questions. Are there any questions?

MR. SIMONSON (Bureau of Public Roads): Aerodynamically speaking, you mentioned the one, two and three blades. Is there a fourth blade, and, if so, what is the objection to it?

MR. SHORT: There is no objection to a four-bladed rotor. There is one four-bladed rotor being built experimentally. The reason we have not gone into four-bladed rotors is because it is much simpler to balance out a three-bladed rotor system, and it does not complicate the controls as much.

The S-51 costs about $80,000, which sounds very expensive. I have in front of me some interesting figures that the Los Angeles Airways—who have been operating air mail routes—have compiled in the first three months of their

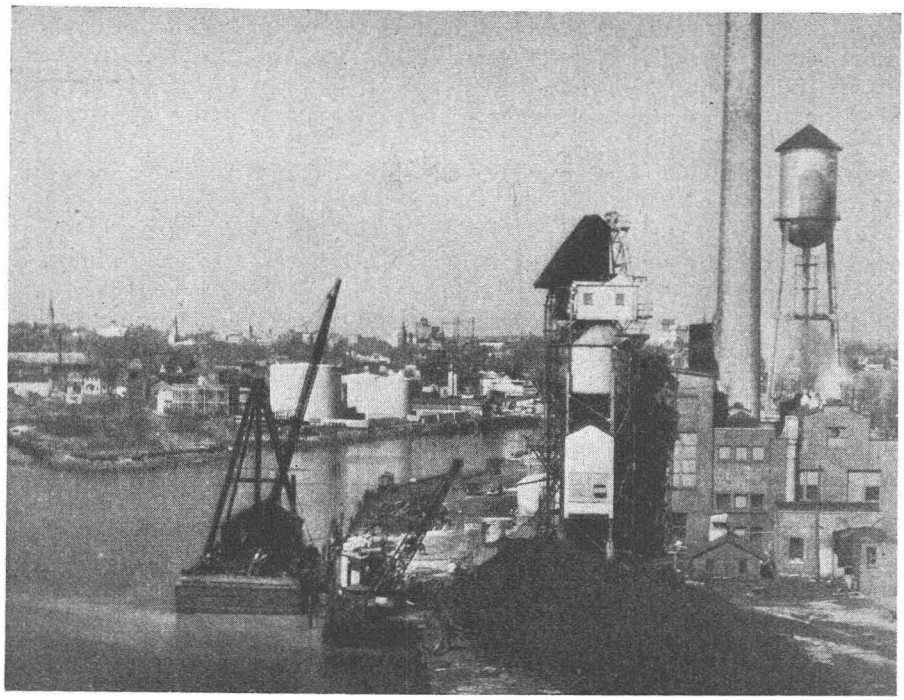

FIG. 9. 100 foot altitude—Sikorsky powerhouse from over canal 1/250 of a second—minus blue—30 MPH.

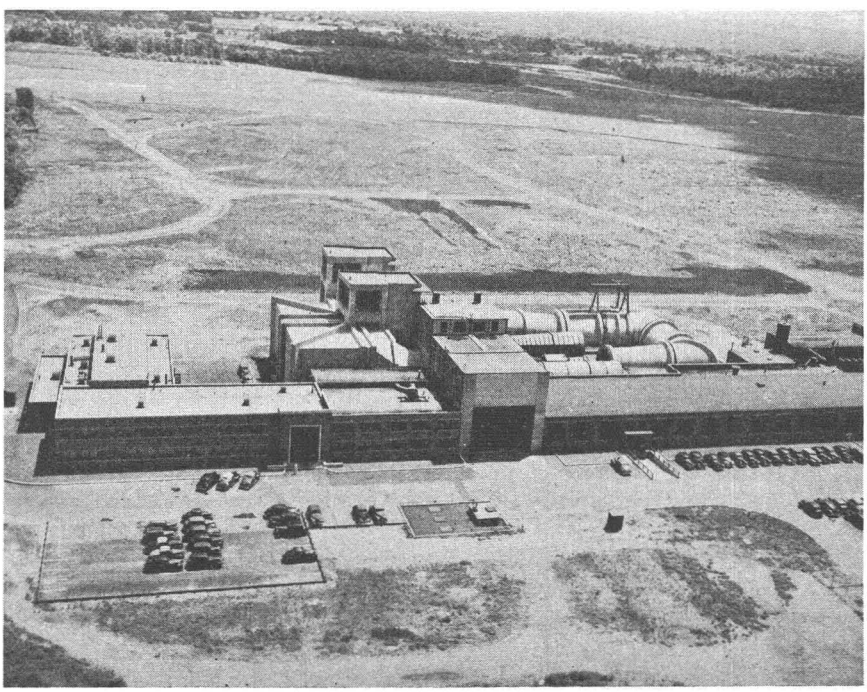

FIG. 10. United Aircraft wind tunnel from 250 foot altitude Speed Graphic 1/200 at 20 MPH.

operations. They found that the total pounds carried in the first three months of operations was 209,097 pounds of mail. They flew 37,073 miles and carried approximately 10,500,000 letters. In November they flew 12,642 miles at a cost of $1.42 per mile, including depreciation, ground maintenance and the entire cost of operating the ship.

Actually, at $80,000 if you can keep the ship busy it is relatively inexpensive to operate.

MR. J. BLYNN WELDEN (U. S. Hydrographic Office): I don't know that I have a question to ask you, but it might be of interest to some to know that the Navy is contemplating using the helicopter for tying in our own survey signals. In the Navy, most of our flying is done before the survey party enters the field. It is quite difficult to tie in these signals with the pictures, so the helicopter is the answer. The survey ship will probably carry one of these machines and fly over the signal and locate it with reference to the pictures and the ground control.

PRESIDENT MASSIE: Thank you very much, Mr. Short, for your informative talk. If you had been here yesterday, you would have seen one of the helicopters in use helping in some of our problems. We have heard of other uses and I am quite sure it will aid in our work.

The meeting will reconvene at one-thirty.