Reconnaissance Branch of the United States Army Air Force. Colonel Cullen has long been identified with aerial photography and mapping. He was commanding officer of the First Mapping Group following Colonel Minton Kaye, and under his direction most of the photographic projects in the Western Hemisphere were set up. Being anxious to get into active combat, he later became commanding officer of the Second Bombardment Squadron operating in Italy during the war. He has not only been responsible for taking photographs and making maps from them, but has put these maps and photographs to use in a way that has been of the utmost importance during the war. I have great pleasure in introducing Colonel Paul C. Cullen.

COLONEL PAUL C. CULLEN: Thank you, Dr. Miller. Good morning, Ladies and Gentlemen. It is a distinct privilege for me to be here to present to you the Army Air Forces' contribution to the successful completion of this war.

You were told at the wartime meetings of this Society that interesting and exciting activities of special interest to you were taking place underneath the blanket of wartime secrecy. Now most of our activities are out from under cover and there can be told a thousand and one tales of our reconnaissance and photogrammetric action.

Today the photogrammetrists both civilian and military stand on the threshold of a difficult era. An era filled with tremendous promise for those with initiative and vigor and similar in many respects to that confronting our forefathers when our Western Country was opened. Now as then the means for progress are relatively meager and limited but determination and inventiveness should repay our photogrammetric industries a thousand fold if the problems are realized and effectively tackled. But before I present these problems for your consideration let me touch upon the activities of the Army Air Forces during the last war.

You have heard the many stories of who won this and who won that during this war but you've never heard that any of the AAF reconnaissance or photo units won any battle or campaign. Nor will you, for that is not their job. But reconnaissance or lack of it can lose the battle and for Germany it did.

At present unsolved is the mystery of why the Germans pulled their reconnaissance aircraft off the daily surveillance of England during the three days preceding D-day of the Normandy Invasion. Germany's failure in this instance meant that tactical surprise was achieved by the Allies despite the fact that portions of the invading fleet were in motion 24 hours too soon. This is only one instance out of many where the lack of or misuse of reconnaissance by the machine which in 1939 had one-third of the Luftwaffe organized as reconnaissance aviation in compliance with the doctrine of General Werner von Fritch and I quote, "The Military organization with the best aerial photo reconnaissance will win the next war." Someone else has said that the "smartest people did not win the war but that the dumbest lost it."

The Army Air Forces in 1941 had next to no reconnaissance aviation and knew it. The task of building the reconnaissance organization, training and equipping it was a heartbreaking one carried through with much fumbling and muddling. Trying to get aircraft for reconnaissance from the fighter and bomber people while we were taking a licking on all fronts in 1942 was like flying without wings and many times the decision had to be made by General Arnold himself.

Remember in 1942 the Axis was on the advance, our lines of communication were threatened, thus the Army Air Forces were forced to pioneer many new air transport and ferry routes. Airports were built in the sub-arctic, in the steaming tropics, on tiny islands and on the deserts. These airports were vital refueling

stops on the lines which fed supplies to our Allies and over which we moved and supplied our own forces. These airports were of little value unless the young pilots and crews could find them. Existing maps were horribly inadequate for air navigation. Thus our first task was to provide aeronautical charts of almost world coverage on a standard series of 1/1,000,000 scale. All kinds of existing data were used in the preparation of this series. Many agencies of the U. S. Government and our Allies, as well as many of our industrial concerns and non-governmental institutions contributed map or terrain data wholeheartedly. But this was not enough and a large program of original photography was undertaken utilizing green pilots and some older civilian photo pilots who were given brief transition to military type aircraft.

The Army Air Forces charted Alaska, the Canadian Arctic regions, the connecting areas in Canada, Greenland, Mexico, Central America, South America, Africa, the Middle East, India, China, the islands of the Pacific and Japan.

Providing aeronautical charts was only one side of the problem. At the same time the blindfolds were lifted from the eyes of our Air and Ground commanders by the assignment to them of reconnaissance units for each air command. Initially we patterned our technique upon that of the British but as the war progressed gradually other techniques evolved, tailored to fit the needs and the differing climates of the various theaters.

When single photo aircraft were unable to return with photo cover of important objectives, a flight of fighters was dispatched to accompany and cover the photo aircraft. This was not infallible protection but did increase the photo coverage on enemy fighter defended objectives.

Cameras in the nose of the F-5 (P-38) Lockheed Lightning were mounted to shoot directly ahead and with a slight depression angle. The pilot came in very low on his objective and many remarkable photos of small difficult objectives were secured by this method of dicing. Oblique cameras mounted at right angles to the path also were used by low flying high speed aircraft to secure information regarding beach defenses and about other stabilized ground situations.

Putting a camera in the P-51 or Mustang and leaving in two of the guns gave our ground force commanders a joker who could sit over the enemy artillery or tank concentrations and report by radio what was going on and at the same time get pictures to prove his story. These are the lads who whistled up the fighter bombers to come and clobber some lucrative enemy target which they had just spotted. Inasmuch as the fighter bomber outfit was in the air waiting for the 'reccy' boys to find and lead them to a target threatening our ground forces, it is easy to understand how little time elapsed between initial discovery and final destruction. This is the system used so successfully by General Patton to guard his flank on the Metz breakthrough and also at Saint.-Lô. If the target was not attacked immediately then the reconnaissanse aircraft returned photos of the target to the commander for future operations.

The field in which the British and Americans outshone our enemies was in the interpretation of our photo cover. You have heard some of the dramatic incidents which our people uncovered as a result of close comparative studies of consecutive photos. The story of the discovery of a V-1 rocket at Peenemunde 12 months before it was used on England has been told by radio and article.

Not so well publicized was the discovery by photo interpretation, of the 96 concrete and steel V-1 launching sites built by the Germans on the French Coast in 1943. These were destroyed by the 8th and 9th Air Forces and the RAF Bomber Command. Photo interpretation was so successful in finding the V-1 sites as rapidly as they were built, that the Germans eventually changed to a

lightly constructed launching site which was put up at night or during poor weather. The alertness of the photo interpreter enabled the bombers in 1943 and early 1944 to knock out a great hazard to our invasion of the continent, so that V-1 bombs did not fall on England until the middle of 1944, which was a year after their discovery by the interpreter.

Statistics can be tiresome but I think you should know that the Army Air Forces photographed 15,000,000 square miles in the route charting program and that 115,000,000 charts or maps of 30 different types were furnished to the Air Forces, the Army, the Navy and our Allies.

The Ninth Air Force used about 750,000 pounds of hypo while making 13,000,000 photographs.

Before the war we taught in our service schools that Western Europe was the best mapped of all the world. If we fought elsewhere we expected trouble in securing adequate map data. Our forces had been in England over a year before it was realized that neither the British nor ourselves had the maps required for the invasion of Normandy.

In this connection the Air Force was called on for specification photography to be used with the Multiplex in preparing the maps. The Luftwaffe was still strong over the continent and we did not have air supremacy, therefore this job could not be done in the way desired by the Engineers but was picked up in bits and pieces when weather and Jerry fighters permitted. Late in '43 and early '44 we were having our unarmed reconnaissance lone wolves intercepted at altitudes as high as 42,000 feet. This is a remarkable fact as the difficulty of interception increases rapidly with altitude. It was reasonable to expect a single airplane to slip through any patrol unobserved at that altitude.

Photo cover was obtained and the Engineers and their contractors through hard work made the maps required by the ground force commanders. The enemy never worked in favor of our photogrammetrists.

When battle conditions permitted us to operate mapping aircraft in the manner desired by the compilers then it was too late to make the maps. Thus the ground side of photogrammetry used negatives which were not entirely satisfactory and through longer effort and hard work, made adequate maps.

The total Army Air Force photographic effort included making over 171,000,000 aerial negatives from all types of airplanes and for various military uses.

To me the worthwhile study of this past war has to do with the reliance and initiative of the young American thrown on his own by force of circumstance of enemy action. This is not one story. It merely has one central theme with thousands of colorations or installments. The ones about which I could enthuse the most have to do with my bomber boys and the marvelous way in which they put their heads down and bored into flak alley on the heavily defended targets held by the Germans. How, when shot down some of them continued to fight the enemy with the partisans for weeks and even months until they returned to our side of the lines. But that is a subject for some other day.

Photographic cover is of little use for the map maker unless he has control. The AAF was forced to secure much of its own horizontal control and it was obtained in the form of astronomic fixes. For this purpose parties consisting of one officer and one or two enlisted men were organized and hastily trained, then flown to the continent on which the control was to be established. Sometimes they were able to use airplanes to all locations, other times they used every conceivable type of transport—rail, steam vessel, jeep, sailboats, rowboats, dugouts, horses, elephants, yaks, burros, walking of course, even human bearers.

I would like to present for you in broad colors the settings for drama truly photogrammetric. Many of you have been in the field. Your imagination can easily fill in the action, the heat, the insects, the poor grub, the absence of mail, the suspense and the boredom.

There is the story of the two AAF parties who were establishing control in Africa behind Montgomery's advancing 8th Army. These parties were operating south from Derna in two weapons carriers along a track reputed to have been cleared of mines and while moving along in column about 100 miles south of Derna the lead truck was suddenly enveloped in flame, smoke and sand. The Teller mine which had been lying in wait for this truck for a long time fortunately did not injure our personnel nor damage the instrumental equipment. Equipment and personnel were transferred to the other weapons carrier and an overnight camp was made in a carefully searched area nearby.

The next morning this vehicle was cautiously turned around and headed back toward Derna. They had retraced yesterday's tracks about 200 yards when another Teller mine blew up the remaining truck. Again sandbagging paid as there were no injuries to personnel. Now, however, they were afoot 100 miles in the desert. The group was split into two parties, one to remain with the equipment and the other to hike 20 miles north to an Arab tent for help. The Arab had but one camel so the Lieutenant, the Arab and the camel set off through the mine field for help. The Arab and this Lieutenant took turns hiking, and riding the camel during the four days and nights which it took them to reach the main road where friendly trucks gave them a lift.

Another party in Tunisia was the first to get a vehicle through a track across that desert in 18 months.

Many of you have had experience in dealing with Government forms and red tape and thus will not be surprised to learn that the control party chieftain was required to return signed vouchers for all funds expended. One party operating in the territory of an ally wished to get a receipt for funds used for train travel but found that only a vice-president of the Railroad was permitted by their regulations to sign. This man was eventually found and his signature duly obtained. It is easy to see that when we lay our red tape over that of some of our allies that not only is the tape of a purplish color but the language also.

The AAF Control parties in China started out with a jeep and trailer combination as far as roads or tracks permitted. The going was terrific, 15 m.p.h. was the maximum speed the terrain allowed, and then the mortality was high on springs. A fuel mixture of 80% alcohol and 20% 100 octane gas did not produce much power nor increase the life of the engine.

Walking every other day yielded about 18 miles on the walking day. The horses were small and made about the same speed. Coolies could carry a sedan chair about 25 miles a day. Our heavy-weight men would require 4 coolies whereas two coolies would haul a small man all day. Yaks were also used to some extent.

One of the Army Air Forces Control Parties started out from Chinese civilization to the back country in order to establish needed positions. It traveled through the gorges of the Yangtze, cross rolling fertile lands, and up upon the high rolling plateau heavily forested with spruce. There were very few signs of human habitation except for the occasional nomadic herdsmen tending flocks of goats and herds of yak. These nomads were wild and fierce in appearance and demeanor and gave every impression of being implacable foes if roused to anger. With them the party was very careful to maintain friendly relations. While they were traveling by mules across this type of country one of the officers, Lt. Wesselhoelft, fell from his mule in an ungainly heap. The Chief of the party im-

mediately realized that he had a very seriously ill man upon his hands. Camp was made on the spot and a study was made of how to communicate with American forces many miles behind. Next morning the sick officer was no better and by noon was paralyzed from the hips down. Working through the Chinese Fighter Control Net a message was sent to the nearest American base requesting medical aid. That same evening at 2000 hours the paralysis reached his diaphragm and the ill man shouted that he could not breathe. The officer in charge, and one of his assistants, immediately began artificial respiration. The patient was mentally depressed and those working on him felt helpless in their lack of medical knowledge. A handbook seemed to indicate that the sick officer was suffering from infantile paralysis (poliomyelitis). Later this diagnosis was confirmed by the doctors. After working all night on the patient giving him artificial respiration, his spirits had been revived to the extent that he was now fighting for his life, although he still could not breathe. The Chinese Fighter Control Net had not returned any word so runners were dispatched to the two American bases. One of the Chinese assistants was ill with bacillary dysentery. The officer in charge, Captain Partenon, and his assistant were nearing physical exhaustion from their constant administration of artificial respiration. One of the Chinese liaison officers went to the nearest magistrate and secured six Chinese soldiers to help them. These were trained by demonstration. Captain Partenon and his assistant had been working for 48 hours administering artificial respiration when help came. The Chinese soldiers who relieved them could not understand that the patient was unable to breathe. A constant watch was necessary in order to insure maintenance of the proper rhythm. It was learned later that the message had gotten through to the American bases and that they were trying to reach this party by airplane but could not do so because of the poor weather. After two weeks doctors were parachuted to them and an air strip was built from which Lt. Wesselhoelft was flown in a Piper cub to the American base. On the next day he was flown to a hospital in India and from thence back to the United States.

The problems confronted by AAF control parties, whether it be the finding of the vice-president of the railroad to sign the vouchers or diplomatic contacts which permit our people to enter the land of our Allies or our friends, or whether they had to meet the emergencies of Teller mines, the poisoned arrows of unfriendly Indians or poliomyelitis in the Chinese hinterland, were met by these young, relatively inexperienced officers with fortitude and determination to successfully complete the mission of establishing control positions.

They were far from the solace of companions when the going was rough. They could not see the effect of their efforts upon the enemy, there were no battle stars and few medals, death thinned their numbers and yet they pressed through uncomplainingly.

As a result the Army Air Forces established 1508 astronomic positions and recovered 2558 previously established positions. This was done with a force 90% of whom had not had previous experience.

Training was confined in the main to the technical aspects of their job and very little emphasis was given to the art of living off the country. Careful selection of personnel had much to do with the ultimate success of this project.

Obviously, this presentation of the Army Air Forces photographic and photogrammetric activity during the past war has been sketchy and does not do justice to the thousands of young Americans, both men and women, in and out of uniform, who made a success of our photographic participation in the final victory.

Our problem, now, is the future defense of our country. This war was fought

mainly with equipment designed prior to 1942. Photography was no exception. It was ended by a development engineered during the war and I have reference to the Atomic Bomb.

The weapons of future wars hold promise of far greater capacities in power and speed than anything which saw combat in this past war. Photogrammetry is working today with the same basic tools in use 20 years ago. Certainly there have been refinements but no new techniques or major developments. The plane table is still required. Geodetic control has been tied to the ground.

Map compilation is expensive and time-consuming and apparently is incapable of being rapidly expanded. If our conception of rocket projectiles or guided missiles is tied to the present methods of 1/25,000 scale mapping then our defensive picture of the future looks dark. If we assume that guided missiles require accurate maps then we need a lot of new mapping. We cannot afford it with present techniques either in time or in money.

Perhaps this problem is too difficult but consider the huge gap now existing between 1/62,500 geographic quadrangle sheet technique and that of the 1/1,000,000 aeronautical chart.

The problems for the photogrammetric industry to solve include night mapping photography, cheaper mapping (i.e. much more rapid) without sacrificing accuracy, and more flexible mapping techniques. By that is meant utilization of photography made at 60,000 feet altitude or 10,000 feet, without a massive outlay of ground equipment.

It is essential that the map-maker's airplane return from flights over hostile territory with all the essential data, i.e. accurate photography and geodetic control. We must be independent of ground observations.

Let me repeat. First, the present multiplex system is too slow. Second, there is too large a gap between the trimetrogon technique and that of the multiplex.

The Army Air Forces hopes to become airborne on all field phases of photogrammetry just as they do on every other phase of our military defense picture. Camera station, geodetic control and final checking. How? I do not know, that is for the industry to answer, but I am confident that American ingenuity and adaptability can devise better systems than those currently in use, and I am sure that the people who will come up with that answer are seated here in front of me now.

I thank you very much.

PRESIDENT MILLER: Thank you, Colonel Cullen, for your very interesting and informative speech. We have time for a few minutes of discussion of Colonel Cullen's speech, if anybody wishes to ask a question from the floor.

MR. REVERE G. SANDERS [Fairchild Camera & Instrument Corp., New York, N. Y.]: Colonel Cullen has told us of the extent to which the Army Air Forces have interested themselves in such things as ground control, and of course we are all familiar with the extensive organization for trimetrogon mapping. I should like just to ask Colonel Cullen what the future plans of the Army Air Forces are. Are the Army Air Forces going to be a continuing active mapping organization in the future?

COLONEL CULLEN: That is certainly the intention of the Army Air Forces. We feel—and this goes into the integration problem—that the Air Forces are best qualified to indicate the type of mapping required for Air Force operation.

Are there any other questions?

MR. GEORGE ARNOLD [Fairchild Camera & Instrument Corp., New York, N. Y.]: Is the Army conducting any experiments at the present time to eliminate

or indicate the amount of tip and tilt in cameras, possibly through gyro-stabilized mounts?

COLONEL CULLEN: A great deal of experimentation is being conducted along those lines. You will see an example in the corner, an attempt to gyro-stabilize the mount. Possibly we will stabilize the image. Does that answer the question? We are not satisfied with present techniques.

Does anyone else have something that would be of interest?

A MEMBER: To what extent is there possibility of using night photography pictures in mapping?

COLONEL CULLEN: Very little experimentation or research has been conducted into that phase, of whether or not we can use photography at night in mapping. There seems to be no real barrier to using the present night photography techniques in mapping. As you undoubtedly understand, during the war we made no attempt to do mapping at night. Our night photography was limited to reconnaissance, to discovering movements. In that connection you would probably be interested in the fact that down in Italy the Germans had us fooled for a long time on a bridge across the Po. Every time we went out there and took pictures of it, the bridge was in the river and we were confident that the Germans were not getting any supplies across. However, one night we had a night photographic outfit take a picture of the bridge, and it was in use. We found out that they had thousands of Italians and Germans who were building from planking (which was concealed during the daytime), a superstructure over which they ran their trains. They had their trains going over on a bridge that was supposed to be under water. It rather had our bomber people fooled, too. So, there is a definite requirement for night photography.

COLONEL MINTON W. KAYNE: Are you at liberty to discuss developments as regards radar signals and producing maps from photographs?

COLONEL CULLEN: We can touch on that very briefly. Part of the reconnaissance conducted was photography for the radar scopes. This was done primarily for the information of the radar scope operators in leading bomber crews to the targets. There seems, again, to be no definite, real reason why the development of radar and the development of the photography of radar presentation will not aid our mapping program, but as it was used, the radar maps which were prepared were for the purpose of informing our radar operators which particular symbol represented the target, the oil refinery, which we were going to hit with our bombers.

I will be around today, and there are several other Air Force officers here, and they will be very happy to answer any questions which may come up.

PRESIDENT MILLER: Thank you very much, Colonel Cullen. Colonel Cullen, I know, has a very important engagement later this morning. We would have liked to have listened to him answer these questions a considerably longer time, but in order to keep on our own schedule as well, we will have to move on to our next speaker.

Our next speaker is Colonel A. G. Matthews, who is Chief of the Military Intelligence Division of the Office of the Chief of Engineers. In this position he has full jurisdiction of the affairs of the Army Map Service and the numerous far-flung mapping activities of the Corps of Engineers. At the outbreak of the war he was in charge of the old Map Reproduction Plant of the Army and was responsible for the building up of the Army Map Service. Later, he saw active service in the Pacific area. With all this background, I am sure you will appreciate what an important person Colonel Matthews is and how privileged we are to hear him talk this morning.