Some Notes on the History of Aerial Reconnaissance (Part I)

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April 1966
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SOME NOTES ON THE HISTORY OF AERIAL RECONNAISSANCE (PART I)

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FOREWORD

BACKGROUND

This paper collects some material which I used to prepare a
speech several years ago.

I was invited to participate in the Open Space and Peace Symposium,
sponsored by Sylvania Electric Products and the Hoover Institution
on War, Revolution, and Peace, held at Stanford University, September
4-6, 1963.

More specifically, I was assigned (or invited) to present a paper
on "The Development of Aerial Reconnaissance from World War I to Korea."
In the course of my continuous association with reconnaissance since
1946, I have accumulated many impressions, data and references, contacts
and photographs; enough, in truth, to begin a history of aerial recon-
naissance, a job not yet done by anyone else. So it was easy to do
this paper—I thought.

I gave the speech and then decided to do the writing in late
1963. What I produced (or reproduced) follows. Vietnam and other
problems have caused me to lay this aside, temporarily at least.

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Various people have urged me not to delay circulation of the material in hand. Hence, this paper is entitled Part I; hopefully, the story will be continued later.

**SOME PERSONAL REMARKS**

World War I to Korea: What a tumultuous, rich and eventful period of history! From the beginning of WW I to the effective end of the major portion of the Korean War was but forty years.

I have been intimately associated with and involved in reconnaissance research and development activities since 1940—a period more than half the length of the period under review. It is therefore understandably difficult to keep any remarks about reconnaissance short; it is even more difficult to keep them entirely objective. True objectivity is an easily exercised privilege of the uninvolved and unconcerned. I admit this freely and early, and thus, I hope to anticipate possible criticism that my remarks may not be entirely fair or broad or those of a true historian.*

Discussing aerial reconnaissance without poring over finely reproduced photographs is frustrating, for above all, aerial reconnaissance has not been a verbal activity but a photographic activity. Reading about reconnaissance alone without examining photographs would be like having a meal composed only of soup and salad. For the entree one must turn to the references listed, especially those which include photographs.

To prevent misrepresentation of my view of this subject, I note that all the references used in this Paper are in my own files. I freely confess they are not complete. An adequate history of reconnaissance in this period will require a book, and a very big one at that, with pictures, heroes, and stories. That book has not yet been written. When the right book is written, it will recount a mixture of science and bravery, of frustration and imagination, and will show how reconnaissance developed from a novelty to a necessity. This paper is a preliminary effort and eventually will become part of a more complete work.

I hope that publication of this account will stimulate readers to correct, extend, fill in, and supplement my data, so that next time around the account will be fuller and better balanced. Extensive and extended quotations are given because of the difficulty many readers would have in locating the sources.
I. INTRODUCTION

In preparing this history, the author has necessarily included material which might be of limited interest to the general reader but which will be significant to the military planner and student. There is good reason for this, for at the end of the Korean War General O. P. Weyland's official report noted that:

An astounding facet of the Korean War was the number of old lessons that had to be relearned. ...It appears that these lessons either were forgotten or were never documented--or if documented, were never disseminated.*

and from another report:

...Progress comes from building on the old, not from continuously rediscovering what is old. Making what turn out to be mistakes is regrettable, but making old and avoidable mistakes is stupid. As has been said before, ignoring history may force one to repeat it...**

Although this paper is limited to the period 1914-1953, there are interesting relevant historical aspects to be traced backward from WW I to the invention of photography in the 1850's. Some of these will help put later developments in perspective, and there will be some references to events and progress in reconnaissance after Korea, to cap the story.


The history of reconnaissance over this period is one of motion:

- Ideas developed into doctrine and practice.
  Gadgets became operational hardware.
  A novelty became a necessity.

Any full account of reconnaissance in this period would have to show a tangled web of science, technology, reaction, arguments, and military and civil applications.

Reconnaissance has had its heroes—many sung, and many more unsung. Fanatics and visionaries, scientists and scholars, operators, tillers, and workers—all have claims for space in the story. But, as noted in the foreword, this first account will be bare, and omissions will be obvious.
II. Some Early History Through the Civil War

It is particularly appropriate to quote from a paper on "Observation Satellites" on the early history of aerial observation. (1)

Man has always taken his vision to the high road, to places of novel perspective. When photography became a practical tool—say, a century ago—he started taking pictures from towers, mountain tops, and balloons, and later from airplanes and rockets. He still uses these camera platforms.

Aerial photography from its beginning conjoined with reconnaissance. Nadar* (1820-1910), a famous French photographer and a key figure in the history of photography, was a pioneer in aerial photography. In 1858, he started the photographic balloon ascents described in his book, Les Memoires du Géant (1864).

Nadar's views on military applications of balloon reconnaissance changed from a refusal to work for Napoleon III in 1859 to active participation as commander of the balloon corps during the siege of Paris (1870-71).

In 1860, J. W. Black of Boston teamed up with "Professor" Sam A. King, a well-known aerialist, to take a balloon photograph of Boston from an altitude of 1211 ft. This photograph was for many years widely regarded as the most successful aerial photograph on record.

In May 1862, Gen. George B. McClellan used balloon photographs in several Civil War battles around Richmond. He made huge maps, superimposed grids on these maps, and furnished telegraph connection between division headquarters and the balloonborne observer, anticipating by about 80 years the role of aerial observers for artillery adjustment.

*Pseudonym for Gaspard Felix Tournachon.
All the early balloon photographers had rather small perspectives compared with the efforts and views of an American named George Lawrence (1868-1938), who started doing aerial photography from balloons and kites in the early 1900's. This remarkable man devised various cameras weighing more than 1000 lbs, which took pictures as large as 4 x 8 ft, and successfully hoisted them by means of balloon kites, and associated control apparatus to heights of several thousand feet. One of his earliest cameras was indeed a panoramic camera--a camera of the type advocated for closeup lunar photography, (2) and one which may be useful also as a camera in observation satellites.

Lawrence was in the vicinity of San Francisco with his fantastic equipment at the time of the great earthquake and fire, April 18, 1906, thus furnishing one of the outstanding historical examples of the match between man and an event.

He hoisted his gigantic camera 2000 ft over disaster-stricken San Francisco, and obtained an 8 x 4½ ft photograph, one of the world's most famous photographs. Seldom realized by viewers of this shot is the fact that this photograph was not made from an airplane, barely invented at this time. In fact, the camera used to make the photograph weighed much more than the Wright Brothers airplane and its pilot!

It is well known that as soon as airplanes were thought to be practical and safe photographs were taken from them. Photographs in World War I, and especially in World War II, were major tools of reconnaissance and intelligence. The civil uses of photography are numerous.
It may be suspected that photography from rockets is a fairly new photographic technique. This is not the case. At a meeting in Stuttgart in 1906, one A. Bujard presented a paper, "Rockets in the Service of Photography".\(^\text{4}\) His paper concerned the work of Alfred Maul, who wanted to use camera-carrying rockets for military reconnaissance. He started with a camera taking pictures 40-mm square (the same size as the picture taken by the miniature Rolleiflex camera). He had troubles, i.e., bad luck—the shutter would not work, the parachute would not open, etc. He finally worked up to larger models (1912) which had a stabilizing gyroscope, weighed 92\(\frac{1}{2}\) lb at takeoff, and carried an 8 x 10 camera to about 2600 ft. But by this time the airplane was coming into its own, and photos from airplanes were easily made. The success of airplanes killed the interest in rockets as photographic platforms.

I must add an immediate footnote to these remarks about photography during the Civil War. Since the previous material was published, I have had occasion to go into this matter more carefully. I am unable to find any documentary reference to the fact that photographs were actually made for military purposes during the Civil War. Visual observation was successfully performed from balloons. This is well documented.

The search for data on the uses of aerial photography in the Civil War led me to several interesting references (Refs. 5-9).

We are fortunate in having the voluminous records compiled by the Historical Division of the Air Material Command at Wright Field in June 1946 on reconnaissance. From these records, a massive work
was prepared. This volume, titled *Reconnaissance Aircraft and Aerial Photographic Equipment, 1915-1945*, (5) is full of fascinating details and references. Chapter I of this book is an account of the historical background of aerial reconnaissance and photography. From that work, the following is quoted: (It would complicate this report excessively to cite the references within this reference, for they are numerous. The reader is referred to the original work for references and documentation.)

A number of "aeronauts" made their way to Washington at the beginning of the Civil War with plans for the use of the balloon for reconnaissance purposes, and several tests and trials of their apparatus were made. One of the names most frequently recalled in this respect is that of Professor T. C. Lowe, who acquired the impressive title of "Chief Aeronaut" of the Army of the Potomac. Professor Lowe successfully directed the artillery fire of the Union Army against Confederate positions in Virginia by means of a telegraph installed in his balloon over Fort Corcoran, Washington, D. C. He was also able to carry out a number of successful observations of Confederate lines in Virginia. The Confederates, "aeronauts" in their own right, made similar observations of Union Army installations in the area. Taking photographs from the air was discussed as early as May 1861, but evidence of their use for military purposes at this early date is not conclusive. There are numerous indications that non-military photographs were taken from the air during these years.

Aerial Photography, by A. I. Shershen, (6) is a text prepared for third- and fourth-year students specializing in aerial photogeodesy in the Soviet Union. This book presents an exceptionally interesting
history of Russian developments in aerial photography along with numerous claims for firsts. On page 7 of this book there is a statement which is undocumented (and in my present judgment, seems to be in error) that "the city of Richmond (Confederate) was photographed at an altitude of 350 meters from a captive balloon." An extensive description of the alleged use of the photography follows. A similar story is repeated in Ref. 7 and unfortunately, is quoted above in a paper by the author.\(^1\)

The Manual of Photogrammetry, published by the American Society of Photogrammetry\(^2\) contains a useful historical account of the development of photogrammetry. ("Photogrammetry" is officially defined by the Committee on Nomenclature of the American Society of Photogrammetry as "the science or art of obtaining reliable measurements by means of photography.") This work refers to the remarkable career of Colonel Aime Laussedat, an officer in the Engineer Corps of the French Army who, starting in 1849, "embarked upon a determined effort to prove that photography could be used with advantage in the preparation of topographic maps" (Ref. 8, p. 2).

Laussedat published a book in which he described his research on methods and instruments for the compilation of topographic maps.* It is undoubtedly this text which is responsible for the story of balloon photography in the Civil War, for on p. 9 of Ref. 8, we find: -

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*This book is not at hand, and I have not seen it. It does not meet my criterion. This citation is from Ref. 8, p. 4, Laussedat, Col. A., Recherches sur les instruments, les méthodes et le dessin topographiques, Paris, Gauthier-Villars; Vol 1, 1898; Vol II, part 1, 1902; part 2, 1903.
The earliest known application of photogrammetry in the United States was by the Union Army, as reported and published in 1888 by Lt. Henry A. Reed, West Point professor, in his book *Photography Applied to Surveying*. Laussedat quotes the following passage from Lt. Reed's book:

During the War of the Secession, captive balloons were frequently employed to obtain information about the surrounding country and the position of the enemy. In May, 1862, the Union Army used them before Richmond, and they succeeded in photographing on a single plate all the countryside between Richmond and Manchester to the west and the Chickahominy to the east; the rivers, the roads, the railroads, the swamps, the pine woods, etc., were all pictured as well as the disposition of the troops. Prints were made from the negatives; one of these remained in the hands of the commanding officer and the other was delivered to the aeronautical unit. Rectangles had been drawn on both of them in equal number and disposition and reference letters had been inscribed on them; and after the subsequent ascensions, the photographs permitted the aeronautical unit to give information on all the events of any importance which took place in each rectangle, information which, in several instances, proved very useful.

By far the most detailed and extensive work(9) on aeronautics in the Union and Confederate armies seems to dispose of this matter, at least to this writer's satisfaction. The extensive research in this voluminous record is summarized by the following statements:

Aerial photography, another possible and valuable function of the balloon service, was apparently not practiced by Lowe's Corps, notwithstanding statements to the contrary that appeared in a number of secondary works (Ref. 9, p. 23).
Subsequently, Haydon remarks:

There is no available evidence, either in Lowe's papers, in the voluminous archives of the War Department, or in the papers of McClellan, Macomb, or Warren, to show that Lowe ever carried on the proposed experiments, or took photographs from his balloons during the war. In November, 1862, he stated in a letter to Major General John G. Parke, Burnside's chief of staff, that he had with him "a set of powerful magnifying lenses with which a photograph three inches square can be magnified to the size twenty feet square." But the letter does not mention any photographic operations; nor did Lowe, in enumerating the auxiliary equipment in his train, include mention of any cameras, or similar apparatus. It is only reasonable to assume that had such service been performed, some mention of it would have appeared in this letter, or in Lowe's long and detailed report of the corps' operations submitted to Secretary Stanton in 1863. The latter document's silence on the subject would seem to indicate conclusively that aerial photographs were not tried in the field, or, if attempted, were unsuccessful. This conclusion is further supported by absence of any photographic materials in the inventories and surviving property accounts of the corps. Cameras and other photographic equipment would not seem to be matériel that Lowe would buy with personal funds; and again, no such items are listed in his claims for reimbursement. Finally, none of the war correspondents whose accounts of the balloon service have been examined, mentions photography from balloons. Surely such a new and unusual activity would not have escaped their inquisitive attention and search for dramatic material. Still more conclusive evidence lies in the fact that no aerial photographs have ever been found in the War Department Archives, or
in the photograph collections in the archives of the Signal Corps. To assume that formerly existing prints of this kind have all been lost is not reasonable, since a number of maps made from the air have survived. It is most unlikely, had aerial photography been practiced, that every print would have disappeared from the files.

The assumption that photography was not practiced is further strengthened by the letter of R. A. Maxwell on August 23, 1863, addressed to Secretary Stanton urging that ballooning in the army be continued for the purpose of photographing enemy positions from the air. Enlarged prints of the hostile works at Manassas, Yorktown, and other theatres of action, Maxwell stated, would have been invaluable to the generals in command. Why not take advantage of this process hitherto neglected, and use it in the future, he concluded. Thus from all the evidence examined, the conclusion follows that aerial photography, though recommended by laymen, scientists, professional photographers, and army officers, was not carried on by the balloon corps. Whether it was tried and found ineffective; whether the many duties that occupied Lowe's time prevented him from adding this service to his other operations; or whether the supervising officers refused to provide the additional funds necessary for its prosecution are all questions that must remain unanswered. (Ref. 9, pp 334-335)

Thus, alas, a wonderful story is laid to rest.

*The extensive references contained within this quotation from Haydon's work are not repeated here.
III. FROM THE CIVIL WAR TO WORLD WAR I

According to Shershen (Ref. 6, p. 7) "...the first attempt to use aerial photography for military purposes was made as early as 1859 in the Austria-Italian War."

He (p. 8) states:

The secret movements of troops under cover of darkness were recorded by the aerial photograph as soon as it was light enough for the operators to work. The burden of large numbers of men, no matter how stealthily they moved, left its mark upon the earth's surface, tracks being left on arable and grass-land alike. Careful study would reveal whether mounted or unmounted troops had been moved, and in what formation and to what extent.

The interpretation of aerial photographs was, of course, a real problem and one of vast importance. It meant considerable training of men of high intelligence, and at first much of the training depended upon guess-work as well as deduction, for it was only by an ever-increasing experience that the interpreters could learn the significance of new details and classify their deductions until they had a reliable photographic key or code upon which to work and through which to teach new recruits. The smallest detail had to be accounted for in terms of military importance. Nothing was too slight to escape the attention of those whose difficult task it was to provide rational explanations of the photographs. Everything revealed in an aerial photograph means something, and in warfare margins of error are neither safe nor officially acknowledged. Accuracy alone was not enough. Speed in copying the photographs and supplying them to Headquarters with correct interpretations was also essential for the successful conduct of operations.
No offensive or defensive operation was undertaken without a preliminary consultation of the photographic records made from the air. Hence the continuous struggle for aerial supremacy. By gaining command of the air and thus more or less complete freedom to undertake photographic operations the Allies had the activities of the enemy and, as we have said, possible future activities (as well as past and present), laid before them like an open book.

While the military operations were undoubtedly more comprehensive and perhaps more valuable than those of the Navy so far as aerial photography is concerned, the camera was not without its uses at sea. Mine-fields were frequently located. Damaged and sunken submarines were "spotted" by means of the oil patches which showed clearly on the prints; and a full photographic record of sea transport within and outside the controlled channels was kept.

Late in WW II, I discovered an obscure work—Airplane Photography, by Herbert E. Ives. (10) This remarkable book has been largely disregarded by workers between WW I and WW II because of its age, and hence its apparent obsolescence. Much to my surprise, I found many of the things that I and others of my group had rediscovered during WW II had been anticipated by this book. Ives' book is a genuine mine of information. A rewarding experience awaits students of aerial photography and reconnaissance when they first scan this volume. Ives says (pp. 15 ff):

Photography from the air had been developed and used to a limited extent before the Great War, but with very few exceptions the work was done from kites, from balloons, and
from dirigibles. Aerial photographs of European cities had figured to a small extent in the illustration of guidebooks, and some aerial photographic maps of cities had been made, notably by the Italian dirigible balloon service. Kites had been employed with success to carry cameras for photographing such objects as active volcanoes, whose phenomena could be observed with unique advantage from the air, and whose location was usually far from balloon or dirigible facilities.

As a result of this pre-war work we had achieved some knowledge of real scientific value as to photographic conditions from the air. Notable among these discoveries was the existence of a veil of haze over the landscape when seen from high altitudes, and the consequent need for sensitive emulsions of considerable contrast, and for color-sensitive plates to be used with color filters.

The development of aerial photography would probably however have advanced but little had it depended merely on the balloon or the kite. As camera carriers their limitations are serious. The kite and the captive balloon cannot navigate from place to place in such a way as to permit the rapid or continuous photography of extended areas. The kite suffers because the camera it supports must be manipulated either from the ground or else by some elaborate mechanism, both for pointing and for handling the exposing and plate changing devices. The free balloon is at the mercy of the winds both as to its direction and its speed of travel. The dirigible balloon, as it now exists after its development during the war, is, it is true, not subject to the shortcomings just mentioned. Indeed, in many ways it is perhaps
superior to the airplane for photographic purposes, since it affords more space for camera and accessories, and is freer from vibration. It is capable also of much slower motion, and can travel with less danger over forests and inaccessible areas where engine failure would force a plane down to probable disaster. But the smaller types as at present built are not designed to fly so high as the airplane, and the dirigibles, both large and small, are far more expensive in space and maintenance than the plane. For this one reason especially they are not likely to be the most used camera carriers of the aerial photographer of the future. Inasmuch as the photographic problems of the plane are more difficult than those of the dirigible and at the same time broader, the subject matter of this book applies with equal force to photographic procedure for dirigibles.

The first photographs seem to have been taken from airplanes in 1909--at least according to my available source material. They could not have been taken much earlier, in any event.

Constance Babington-Smith, the most famous photo-interpreter of World War II, writes (Ref. 7, p. 3):

Photographs were first taken from actual airplanes in 1909, and again America and France led the way. On April 24, 1909, Wilbur Wright himself, accompanied by a photographer whose name is unrecorded, took off from Centocelle near Rome, and succeeded in obtaining a series of cinematograph pictures. At about the same time French photographers started experimenting on similar lines, and the first effective stills were those taken by M. Meurisse in December of 1909. During the next five years the work of the pioneers continued apace, and the way was soon open for the successes of the First World War."
IV. AERIAL RECONNAISSANCE IN WORLD WAR I

The most romantic account of the introduction of the aerial camera into military reconnaissance is found in Ref. 11. This book, published midway between WW I and WW II, justifies the claim of its title.*

From pages 5 and 6 of this interesting compendium, we find:

The progress of the heavier-than-air machine and the camera, side by side as it were, is interesting. In the early stages of the war the aeroplane was used mainly for offensive and defensive purposes, and to assist the land and sea services by carrying out observation work, the observer making his reconnaissance by ordinary visual methods. His duty was to act as an aerial detective, making notes of the movements of troops and recording on maps the position of trenches, ammunition dumps and the like. He had to rely chiefly upon his visual observations and an intelligence which would grow keener only by continued experience as an observer. An intuitive facility for grasping and understanding the significance of small details was, of course, an undeniably important gift, but it could not be depended upon in every single observer who took the air for reconnaissance work.

*The title page of this book is a visual delight:

AERIAL PHOTOGRAPHY
A Comprehensive Survey of
Its Practice & Development
By
Sir Alan J. Cobham, K.B.E., A.F.C.
and Introductory Notes
By
Sir Peter Clutterbuck, C.I.E., C.B.E.
and
Sir Felix J. C. Pole

American
Photographic Publishing Co.,
428, Newbury Street,
Boston, Mass.
The human liability to err rendered visual methods of observation open to certain strong objections, and it was with some relief that many welcomed the mechanical precision of the camera.

Exactly how the aerial camera was first introduced for military and naval reconnaissance is a speculative problem. The use of many notable inventions has been ascribed to accident, and applied photography from the air is no exception. It has been reported, whether accurately or not we cannot say, that in the early days of the war, a private soldier managed to obtain a flight in a battle 'plane over the front. He carried, against the rules, a small camera with him, and photographed whatever happened to interest him during the journey. When the machine returned it was discovered that the passenger had carried a camera. The films were accordingly confiscated and developed. To the astonishment of the authorities the films provided accurate and detailed information which the trained eyes of an observer had previously missed. The private soldier had unwittingly provided a permanent record which could be studied and interpreted by many eyes and many minds. Another report credits Germany with the introduction of aerial photography in warfare. Although the British were carrying out a few experiments, it was not until a camera on a captured enemy craft revealed vital military information that a thorough investigation of the merits of aerial photography was made. One of the co-authors of this book remembers a number of German flying pupils who came to England before the war and who were discovered to have carried cameras during their advanced practice flights. It is his theory that the system of sending German pupils to England to learn to fly was a clever espionage trick, showing much forethought and perhaps
a considerable knowledge of aerial photography.

If all stories have some foundation in fact it is probable that the soldier incident described above is more than an allegory. Be that as it may, the time came when it was realized that the record of an aerial camera was likely to embrace more than that of the ordinary visual observer.

Ives' *Development of Airplane Photography in the Great War* (Ret. 10, pp 16, ff) on the problems and opportunities encountered in WW 1, comments:

The airplane has totally changed the nature of warfare. It has almost eliminated the element of surprise, by rendering impossible that secrecy which formerly protected the accumulation of stores, or the gathering of forces for the attack, a flanking movement or a "strategic retreat." To the side having command of the air the plans and activities of the enemy are an open book. It is true that more is heard of combats between planes than of the routine task of collecting information, and the public mind is more apt to be impressed by the fighting and bombing aspects of aerial warfare. Nevertheless, the fact remains that the chief use of the airplane in war is reconnaissance. The airplane is "the eye of the army."

In the early days of the war, observation was visual. It was the task of the observer in the plane to sketch the outlines of trenches, to count the vehicles in a transport train, to estimate the numbers of marching men, to record the guns in an artillery emplacement and to form an idea of their size. But the capacity of the eye for including and studying all the objects in a large area, particularly when moving at high speed,
was soon found to be quite too small to properly utilize the time and opportunities available in the air. Moreover, the constant watching of the sky for the "hun in the sun" distracted the observer time and time again from attention to the earth below. Very early in the war, therefore, men's minds turned to photography. The all-seeing and recording eye of the camera took the place of the observer in every kind of work except artillery fire control and similar problems which require immediate communication between plane and earth.

The volume of work done by the photographic sections of the military air service steadily increased until toward the end of the war it became truly enormous. The aerial negatives made per month in the British service alone mounted into the scores of thousands, and the prints distributed in the same period numbered in the neighborhood of a million. The task of interpreting aerial photographs became a highly specialized study. An entirely new activity— that of making photographic mosaic maps and of maintaining them correct from day to day— usurped first place among topographic problems. By the close of the war scarcely a single military operation was undertaken without the preliminary of aerial photographic information. Photography was depended on to discover the objectives for artillery and bombing, and to record the results of the subsequent "shoots" and bomb explosions. The exact configurations of front, second, third line and communicating trenches, the machine gun and mortar positions, the "pill boxes," the organized shell holes, the listening posts, and the barbed wire, were all revealed, studied and attacked entirely on the evidence of the airplane camera. Toward the end of the war important troop movements were possible only under the cover of darkness, while the development of high intensity flash-lights threatened to expose even these to pitiless publicity.
LIMITATIONS TO AIRPLANE PHOTOGRAPHY SET BY WAR CONDITIONS:

The ability of the pilot to take the modern high-powered plane over any chosen point at any desired altitude in almost any condition of wind or weather gives to the plane an essential advantage over the photographic kites and balloons of pre-war days. There are, however, certain disadvantages in the use of the plane which must be overcome in the design of the photographic apparatus and in the method of its use. Some few of these disadvantages are inherent in the plane itself; for instance, the necessity for high speed in order to remain in the air, and the vibration due to the constantly running engine. Others are peculiar to war conditions, and their elimination in planes for peace-time photography will give great opportunities for the development of aerial photography as a science.

Chief among the war-time limitations is that of economy of space and weight. A war plane must carry a certain equipment of guns, radio-telegraphic apparatus and other instruments, all of which must be readily accessible. Many planes have duplicate controls in the rear cockpit to enable the observer to bring the plane to earth in case of accident to the pilot. Armament and controls demand space which must be subtracted from quarters already cramped, so that in most designs of planes the photographic outfit must be accommodated in locations and spaces wretchedly inadequate for it. Economy in weight is pushed to the last extreme, for every ounce saved means increased ceiling and radius of action, a greater bombing load, more ammunition, or fuel for a longer flight. Hence comes the constant pressure to limit the weight of photographic and other apparatus, even though the tasks required of the camera constantly call for larger rather than smaller equipment.
To another military necessity is due in great measure the forced development of aerial photographic apparatus in the direction of automatic operation. The practice of entrusting the actual taking of the pictures to observers with no photographic knowledge, whose function was merely to "press the button" at the proper time, necessitated cameras as simple in operation as possible. The multiplicity of tasks assigned to the observer, and in particular the ever vital one of watching for enemy aircraft, made the development of largely or wholly automatic cameras the wartime ideal of all aerial photographic services. Whether the freeing of the observer from other tasks will relegate the necessarily complex and expensive automatic camera to strictly military use remains to be seen.

Except for certain internal evidence as to the date of the writing, (which was completed in November, 1919) one could well imagine that Ives' words were written in this decade. They well define much current thinking on the relation and competition between reconnaissance equipment and aircraft, and their fighting counterparts.

This book by Ives is an extraordinary collection of progressive ideas, suggestions, and methods, many of which, as I noted earlier, were rediscovered during WW II. It will prove to be a sobering experience for anyone who has worked in reconnaissance to find and read a copy of this old book. Also this book contains an excellent discussion of the early cameras used in WW I by the French, English, Americans and Germans.

Constance Babington Smith writes of this early period (Ref. 7):

When August 1914 came, however, aerial reconnaissance was still primarily visual, and such were the first reconnaissance flights
of the Royal Flying Corps, made on August 19 by Captain Joubert de la Ferté and Lieutenant G. W. Mapplebeck. But the idea of using the camera to supplement the human eye was already being pursued by both sides. At first the French were ahead in this field, but the British were soon following their lead and in due course Lieutenant J. T. C. Moore-Brabizon was put in charge of a small photographic unit. By March 1915 a trench map prepared chiefly from aerial photographs was used with great success by Sir Douglas Haig in the attack at Neuve Chapelle and from then on there was a continual urgent demand for photographic reconnaissance, both for making maps and for checking enemy activity.

At the start of the war some of the Army diehards had felt it was unseemly to photograph the German rear positions, but these scruples were soon forgotten. By mid-1915 both sides were hard at it, and both sides were realizing that steps must be taken to prevent the enemy from recording their secrets from above. This need stimulated the rapid development of aircraft equipped with guns, for the work of the reconnaissance planes was so vital that they had to be protected—by an escort of specialized fighting aircraft.

Later in the war, photography also proved of decisive value in Egypt and Palestine; firstly for mapping, because in many areas the existing maps were no use. But one of the photographic officers of the R.F.C. who took part in this work, Lieutenant Hugh Hamshaw Thomas, became much interested in studying the photographs further; and thus he gradually accumulated a fund of knowledge about what military installations look like from above. It was largely thanks to him that much invaluable data on the Turkish fortifications and batteries was available when General Allenby came to plan his attacks.
By 1918, photographic reconnaissance was being used to a lavish extent. There had been great advances in camera design and photographic techniques, as well as in the methods of deriving information from the pictures—methods which soon became known as photographic interpretation. A great revolution had taken place in the whole field of military intelligence. The traditional methods of obtaining information—the reports of secret agents, censors, and interrogators—were not superseded, but they were supplemented, in the same revolutionary manner that the traditional methods of communication had been supplemented by the telephone and wireless telegraphy. By the time of the Armistice, photographic intelligence had indeed proved itself, and was recognized on every hand as the indispensable eye of a modern army. But largely because of the technical limitations of the day—the performance and range of the aircraft and the scope of the cameras—it had come to be regarded as essentially of tactical value, and after the war this concept became frozen stiff in the thinking of the staff colleges of the world.

The best descriptions of the kinds of cameras developed and used during World War I are found in Ives (Ref. 10), and in the very rich Ref. 5. Reference 5 contains as well a detailed account of the procurement problems and history of aerial photographic equipment during World War I.

Shershen's book (6) is a thoroughgoing and well-written technical book which happily, in contrast to many technical books, contains a lengthy account of the early history of the subject as seen from the Soviet Union.

There is an abundance of technical material on early cameras
and the scientists and technical people associated with the early work. This section is replete with claims for numerous "firsts" in camera design, mechanical features, and the invention of roll film; and these are accompanied by non-technical patriotic phrases and sentiments. However, it is Shershens account of Russian aerial photography in WW I that is of interest at this point (Ref. 6, pp. 9 ff):

The first aerial photographic flight in Russia was made during military maneuvers in 1910.

During the first stage of the war, aerial reconnaissance was carried out exclusively by visual observation. However, after the combatants went over to the stage of trench warfare the general staffs were in dire need of documentary aerial reconnaissance. Aerial reconnaissance was introduced into the armies which could now obtain by photographic means information of the enemy's manpower, weapons and equipment, his defense installations, lines of communications and rear concentrations. In addition, the aerial photographic reconnaissance service was employed for the correction and adjustment of available photographic maps, or for making new plans and maps for military purposes.

The increase in the role of aerial photographic reconnaissance contributed no little to the improvement of the means of defense against enemy air raids. Visual aerial reconnaissance from low altitudes became increasingly perilous, while observation from high altitudes did not give fully satisfactory results. The accuracy and full coverage of reconnaissance data, and their objectivity and documentary value could only be assured
by means of an aerial camera with a long focal length camera.

Russian aerial photography was given its first serious operational application on the first of November 1914 with the mission of improving the map data of the strong fortress Peremyshl, then under siege by the Russian troops.

...The importance of Russian aerial photography rapidly increased in the first World War. During the last stages of the war hardly an operation was carried out without preliminary aerial photographic reconnaissance.

Operational results showed that only on those fronts where aerial-photographic reconnaissance was given serious consideration, was the success of an offensive or defensive operation completely assured. On the other hand, insufficient evaluation of the role of aerial photographic reconnaissance led in general to a complete failure of the operation undertaken.

It would be enough to refer to the remarkable operation of the break-through on the Southwestern Front in 1916 under General A. A. Brusilov. This historic operation was undertaken after a detailed study of the strongly fortified enemy positions as revealed by a well-planned aerial photographic mission.

The other side of the coin could be observed on our Northern and Western Fronts where offensive operations of the Russian armies, which were undertaken in the same year, were not insured by aerial photographic reconnaissance and operational liaison. These operations paid dearly in heavy manpower and equipment losses and resulted in failure. Throughout the first World War the Russian Army Air Force took 1.5 million aerial photographs.
From Ref. 5 we quote the following on reconnaissance in WW I. As before, the references cited within this reference are deleted.

The outbreak of hostilities in Europe found the Central Powers best equipped technically for work in aerial photography. For one example, the Germans had learned to heat their cameras with electricity to assure more efficient performance of the apparatus at higher altitudes. After a short while it became common practice on the part of the Germans to photograph the entire active Western front every two weeks. In 1918 the German army alone had in use 2,000 mapping cameras and 100 automatic film cameras for large size pictures and were taking about 4,000 photographs per day.

Great Britain and France were quick to take the necessary steps to put the camera to work for them in the field once hostilities began. Britain acquired some experience in the photographic field in the course of making aerial photographs for maps of Egypt and the Suez Canal Zone. The British also produced some mosaics of areas in the Near East. As a result they were able to put aerial photographic organizations into operation on the Western Front in a comparatively short time.

The first British photographic groups were put together in a somewhat hasty and disorganized fashion. However, under the direction of Major J. T. C. Moore-Barbizon who was a pioneer in the field of aerial photography and who later became head of the photographic work in France, and Major C. M. Campbell, who was in charge of photographic activities in London, the organization and equipping of aerial photographic units was steadily improved. Cameras were tried and tested, and cameras designed expressly for aerial photography were put into production, so that as air activity increased, the RAF alone was soon producing
an average of 1,000 exposures and prints daily.

The French probably acted with greater celerity than the British, for they were the first to try out aerial photography in the field and to use the results for military purposes. The French photographic section was largely under the control of camera designers and scientific men, and as a result apparatus of a more complex nature than that of the British was developed. Cameras of French design served as the basis of much of United States production in succeeding months.

In the United States aerial photography achieved a certain degree of military usefulness prior to the entry of this country into the European War. The First Aero Squadron under the command of Major B. D. Toulois carried out air operations on the Mexican border in conjunction with General Pershing's punitive expedition of 1916. Reconnaissance missions and photographic work were carried on over the border area, with flights totaling 19,000 miles, for the most part employing the G.E.M. camera, one of the two cameras first constructed in this country for aerial photographic purposes. A total of 120 of these cameras were ordered by the United States for these operations and for training purposes. One additional camera, the Brock "N" type, antedates World War I. It required actual entrance into the war to bring about any great interest in the design and production of new aerial photographic equipment and in the development of aerial reconnaissance techniques.

How did we do in World War I? Again, from Ref. 5, which has an extensive discussion on this matter, we take the following material:
World War I brought about the introduction of aerial photography as a military activity of primary importance, and profound effects on the tactics of war on the Western Front were apparent as a result of this introduction. Visual observation from the air was a troublesome enough factor for tacticians to deal with, but once it had occurred to some individual to take a camera along on observation flights to substantiate and supplement the report of the observer, aerial reconnaissance became sufficiently accurate and detailed that it had to be considered in the planning of any major operation.

At first reconnaissance operations on both sides went on more or less unhindered. However, it eventually occurred to each of the opposing forces that if its own operations of this nature were as successful in gathering information as they appeared to be, the chances were approximately equal that the enemy was doing about as well with aerial reconnaissance. Observation airplanes then began to be interrupted and aerial combat developed. German and Allied reconnaissance operations were so successful, however, that the close of 1917 marked the end of all major troop movements in the European theater during the day.

During the first two years of the war in Europe, U.S. reconnaissance aviation was concentrated on the Mexican border. But, of course, actual entrance into hostilities brought about acceleration and development of the aerial photographic system and equipment. New administrative charts were created as were new Army regulations. A Photographic Section was created, and the normal apparatus of military activities swung into action. A training organization was established at Langley Field in 1917.
Soon after this, another school for aerial photography went into operation at Cornell University in Ithaca, and shortly afterwards another was established at Fort Sill in Oklahoma. Enlisted men were trained in photography at Madison Barracks, New York, at Langley Field, the Eastman Kodak Company, and Cornell University. The organization at Langley Field was charged with all matters pertaining to instruction and experimentation in bombing, photography, radio and telegraphy. In October, 1917, McCook Field at Dayton was established.

The French and British contributed camera designs to the United States. The French camera was the DeRam, which was a large camera, had a focal length of 20 in., weighed about 90 lbs, took a plate size approximately 7 x 9 in. The "L" type camera was adapted from a British production model. About 750 of this type were made in this country, 300 of them being shipped abroad. The basic characteristics of this camera were focal length of 8½ or 10 in., weight 35 lbs, 4 x 5 in. format, and magazine capacity of 24 negatives.

The Folmer film camera manufactured by the Folmer & Schuring Division of Eastman Kodak (later to become the Folmer-Graflex Corporation) was set up for production with 100 cameras on contract for delivery scheduled for November, 1918, a date better remembered for other reasons.

During the greater part of WW II, French-made cameras such as the DeRam, the Gaumont and others, and British cameras were the principal source of supply for the United States forces. Some estimates have been made that 7/8 of the equipment which A E F observers used were of French manufacture. Plate cameras were the principal cameras of WW I. The Rollfilm camera, despite its attractive features and principle, did not work out well in practice. Film flatness, problems of film definition,
etc., produced an overwhelming vote for the aerial glass plate camera.

According to Ref. 5:

The military use of aerial photographs was a relatively new development and reconnaissance photographs had to be "sold" to many men high in authority. Some, of course, remained unconvinced to the end. However, the demand for aerial photographs showed a consistent increase throughout the course of the war. During the Meuse-Argonne offensive, for example, 56,000 prints were produced and delivered to various AEF activities in a period of approximately four days. On many occasions during various large offensives, due to a dearth of personnel, photographic sections at the front worked continuously for sixty hours, turning out an average of 17,000 prints per day per section. Total production from 1 July to 11 November 1918 mounted to 1,300,000 prints. Toward the closing months of the war aerial photographs were handled so efficiently that many cases were recorded where only twenty minutes elapsed from the time an important photograph of enemy territory was taken until it had been brought to ground, developed, printed, interpreted and used as a basis for giving American batteries the proper range for artillery fire.
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