AIR CORPS TACTICAL SCHOOL

MAXWELL FIELD, ALA.

1935–1936

PURSUIT AVIATION

" Problems

[redacted]

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

ILLUSTRATIVE PROBLEM NO. 1

SECTION I

SITUATION AND REQUIREMENT

1. GENERAL SITUATION.--a. MAPS.--Special Map for Air Corps Problems, scale 1:500,000.

b. The general situation for this problem is the same as that described in the general and special situation for Map Problem No. 1. A resumé thereof is as follows:

(1) Boundary between states.--The general line: Delaware Bay--Chesapeake and Delaware Canal--Susquehanna River--800 grid line forms part of the boundary between two states, Blue (north) and Red (south).

(2) Red declared war upon Blue 1 April. The Red Air Force began immediately the bombing of Blue industrial centers and rail communications. Red observation aviation has been active, deep in Blue territory, and over the Blue Air Force area. Red pursuit has been employed primarily to provide security for the Red Air Force on the ground.

(3) Blue retaliated, with her air force operating primarily against the Red Air Force. Blue Air Force observation aviation met with heavy resistance and incurred some losses in locating and photographing Red airdromes.

(4) Both Blue and Red have established effective aircraft reporting services, permitting their pursuit forces to operate in defense of their respective air force areas and establishments in their vicinity.

P-1
36-250
3-13-36
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(5) Blue Air Force units are located as follows:

Headquarters: Paterson (630-890)

1st Air Division: In the area: Crosswicks (590-795)--Frenchtown (545-840)--Hillburn (620-915)--Keyport (630-830).

2d Air Division: In the area: Frenchtown (545-840)--Kunkletown (510-880)--Huguenot (590-950)--Hillburn (620-915).

1st Pursuit Wing: Wing Headquarters: Bethlehem (515-850).

1st Pursuit Group: On squadron airdromes in the vicinity of Allentown (510-850).

2d Pursuit Group: On squadron airdromes in the vicinity of Quakerstown (520-820).

3d Pursuit Group: On squadron airdromes in the vicinity of New Hope (560-815).

11th Observation Group: On squadron airdromes in the vicinity of Paterson (630-890).

(6) Red Air Force units have been located as follows:

Red Pursuit Group area in the vicinity of Springfield (360-620).

Red Pursuit Group area in the vicinity of Herndon (340-650).

Red Bombardment Group area in the vicinity of Orange (270-560).

Red Bombardment Group area in the vicinity of Fredericksburg (330-565).

Red Attack Group area in the vicinity of Culpepper (280-590).

Unoccupied landing fields in the vicinity of Brandywine (385-615).

(7) Beginning at daylight, 12 April, the Blue Air Force Commander undertook to bring about decisive action against the Red Air Force by co-ordinating the efforts of all units of the Blue

First Air Force. The Red bombardment groups at Orange and Fredericksburg, and the Red Attack Group at Culpepper were attacked. Rail communications leading into and within the Red Air Force area were attacked. The Blue 11th Observation Group continued intensive reconnaissance in an effort to locate and photograph additional Red airdromes. The Blue 1st Pursuit Wing conducted an offensive operation against Red pursuit in general support of the Blue Air Force operations, and provided security for the Blue Air Force.

2. SPECIAL SITUATION AS OF 6:00 PM, 12 APRIL.--a. Additional Red airdromes have been located and photographed at the following points:

Red Bombardment Group Area in the vicinity of Tyler (305-520).

Red Attack Group Area in the vicinity of Quantico (345-595).

The airdromes in the vicinity of Brandywine have not been occupied.

b. G-2 reports indicate that as a result of the operations of the Blue First Air Force on 12 April, the Red bombardment groups at Orange and Fredericksburg will be unable to resume operations within the next twenty-four hours.

c. Red observation aviation was active throughout the day of 12 April, over the Blue Air Force Area. Many of the Red observation airplanes were driven off and some destroyed by Blue pursuit.

d. Due to strenuous operations for the past few days, and in furtherance of the general plan, it is contemplated that no units of the Blue 1st and 2d Air Divisions will operate between daylight and 12:00 noon, 13 April.

e. At 8:00 PM, 12 April, all components of the Blue First Air Force received the formal field order for the operations of that force on 13 April. Extracts from this field order are as follows:

* * * * * * * * * *

3. a. The 1st Pursuit Wing will maintain not less than two groups on the alert from 4:30 AM to 8:30 AM, and not less than one group from 8:30 AM to 12:00 noon, 13 April, prepared to deny hostile aerial operations in order to provide security for the Blue Air Force.

b. The 11th Observation Group will * * * * *

f. At 10:00 PM, 12 April, all units of the 1st Pursuit Wing received the formal field order for the operations of that force from 4:30 AM to 12:00 noon, 13 April. Extracts from this field order are as follows:

* * * * * * * * * *

2. This wing will be on the alert from 4:30 AM to 12:00 noon, 13 April, prepared to deny hostile aerial operations in order to provide security for the Blue Air Force.

3. a. The 1st Pursuit Group will be on the alert from 4:30 AM to 8:30 AM. After 8:30 AM, it will remain in readiness.

   b. The 2d Pursuit Group will be in readiness from 4:30 AM to 8:30 AM. It will be on the alert from 8:30 AM to 12:00 noon.

   c. The 3d Pursuit Group will be on the alert from 4:30 AM to 8:30 AM. After 8:30 AM, it will remain in readiness.

   x. Units on the alert will operate only upon orders from these headquarters.

* * * * * * * * * * * *

3. SPECIAL SITUATION, CONTINUED.--Beginning at 5:32 AM, 13 April, messages from observation posts of the aircraft reporting service, were received at headquarters, 1st Pursuit Wing. The following are extracts from these messages:

"5:32 AM, Red bombardment group, wedge formation ENTLERVILLE (340-805), 10,000 feet, course 17°."

"5:39 AM, Red bombardment group, wedge formation, 4 miles west of MILLERSTOWN (355-830), 13,000 feet, changed course to 33°."

"5:45 AM, Red bombardment group, wedge formation 3 miles east of PAXTONVILLE (365-865), 15,000 feet, course 33°."

"5:50 AM, Red bombardment group, wedge formation, LEWISBURG (380-885), 15,000 feet, course 56°."

"5:56 AM, Red bombardment group, wedge formation, JERSEYTOWN (410-905), 15,000 feet, course 56°."

"5:58 AM, Red attack group, column of squadrons, 4 miles west of HANCOCK BRIDGE (515-710), 200 feet, course 52°."

36250

"6:00 AM, Red bombardment group, wedge formation, BENTON (425-915), 15,000 feet, changed course to 90°."

"6:04 AM, Red attack group column of squadrons, 3 miles east of WOODSTOWN (535-735), 300 feet, course 52°."

"6:06 AM, Red bombardment group, wedge formation, 2 miles west of NANTICOKE (460-915), 15,000 feet, course 90°."

"6:10 AM, Red attack group, column of squadrons CLEMENTON (560-750), 300 feet, course 52°."

"6:12 AM, Red bombardment group, wedge formation, 4 miles east of BEAR CREEK (485-915), 15,000 feet, course 90°."

"6:16 AM, Red attack group, column of squadrons, 1 mile southwest of PEMBERTON (585-770), 300 feet, course 52°."

"6:18 AM, Red bombardment group, wedge formation, 3 miles east of TOBYHANNA (515-915), 15,000 feet, course 90°."

4. REQUIREMENT.--a. Give in detail the actions taken and orders issued by Brigadier General "B", commanding the 1st Pursuit Wing, and reasons therefor, from 5:32 AM, to 6:30 AM, 13 April. Cover only such necessary actions and orders as apply to the denial of hostile aerial operations.

b. If, in your opinion, combat should take place prior to the receipt of any of the messages given in Special Situation (paragraph 3), disregard those messages affected.

c. State time, place, and Red unit or units attacked by Blue pursuit, if such action is ordered. This information will be given as a message or messages from observation post or posts. A form of message is as follows:

____________ Pursuit ____________________
(Time) (Unit or units - state size)

Attacking Red ________________ Over __________
(Unit - state what unit) (Place)

NOTE.--a. Brigadier General "B" has communications with all Blue pursuit group headquarters by both radio and direct wire telephone.

b. Blue pursuit airplanes have two-way radio (telephone in group and squadron commanders' planes). All other pilots have receiving sets only.

c. The weather is clear, with light northerly winds.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

ILLUSTRATIVE PROBLEM NO. 1

SECTION II

A SOLUTION

5. A SOLUTION.--a. Brigadier General "B" received the message at 5:32 AM and directed S-2 to plot the course of the Red bombardment group. He also directed that all messages pertaining to Red aerial activities be promptly relayed to each Blue pursuit group on the alert. Then with S-3 and S-2, he watched the progress of the Red bombardment group on the map.

b. He noted the change in course of the Red bombardment group at 5:39 AM, and, together with S-2, made a study of time and space factors.

c. Brigadier General "B" received the message at 5:50 AM, noted the change in course, and issued the following order to the 1st Pursuit Group:

"Take off immediately, attack and destroy the Red bombardment group reported over LEWISBURG, 5:50 AM, 15,000 feet, course 56°."

He also directed that all further information relating to the Red bombardment group be radioed immediately to the 1st Pursuit Group in the air.

d. Brigadier General B's reasons for his above actions are as follows:

The Red Bombardment Group had made two changes in course since first reported over Blue territory. These changes in course had brought it into the zone of action of Blue pursuit, and a study of time and space factors indicated that if a timely interception was to be made, Blue pursuit must take off immediately.

Brigadier General "B" considered ordering off both pursuit groups against the Red bombardment group. He concluded, however, that he could wait at least ten minutes before ordering off the 3d Pursuit Group, as only one group could attack at a time. Also, the ordering off of the 3d Pursuit Group would leave no Blue pursuit on the alert.

e. At 5:52 AM, he directed S-3 to order the 2d Pursuit Group to go on the alert at 6:52 AM.

f. Brigadier General "B" received the message at 5:58 AM and issued the following orders to the 3d Pursuit Group:

> "Take off immediately, attack and destroy the Red attack group reported four miles west of HANCOCK BRIDGE, 5:58 AM, 200 feet, course 52°."

He also directed that all further information relating to the Red attack group be radioed immediately to the 3d Pursuit Group in the air.

Brigadier General B's reasons for his above actions are as follows:

> The Red attack group was within the zone of action of Blue pursuit. A study of time and space factors indicated that the 3d Pursuit Group must take off immediately in order to make a timely interception of this force.

h. The following messages from observation posts were received:

> "6:09 AM, pursuit group attacking Red bombardment group over SUGAR NOTCH (470-915)."

> "6:13 AM, pursuit group attacking Red attack group over MEDFORD (575-765)."

56250

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

MAP PROBLEM NO. 1

SECTION I

SITUATION AND REQUIREMENT

1. GENERAL SITUATION.--a. MAPS.--State of Alabama, U. S. Geological Survey, (1933), 1:500,000.

b. (1) The Mississippi--Alabama state line forms the boundary between two hostile states, Blue (east) and Red (west).

(2) Special situation (Blue).--At 1:00 PM, 27 March, the Blue First Army was opposed by a Red army on the line: Rosemary--Newbern--Uniontown--Lamison.

(3) The Blue First Air Force occupies airdromes in the area, Eufaula--Troy--Montgomery--Alexander City--Lanett. The 1st Pursuit Group occupies airdromes as follows: Group Headquarters, 1st Pursuit Squadron and 84th Service Squadron, Maxwell Field; the 2d and 3d Pursuit Squadrons, Municipal Airport; the 4th Pursuit Squadron, City Airport.

(4) Blue has organized and is operating an Air Force Alert Net covering the entire state of Alabama south of the 34° parallel of latitude and east of the Red Army front.

c. The Red Air Force, of approximately the same strength and organization as the First Blue Air Force, has been located in an airdrome area in the vicinity of Jackson, Mississippi (not on Map). Reports indicate that the Reds are operating an alert net covering the entire state of Mississippi.

2. SPECIAL SITUATION AS OF 1:00 PM, 27 MARCH.-- a. Beginning at dawn, 27 March, the Blue First Air Force engaged in vigorous offensive action against the Red Air Force. All Red bombardment and attack airdromes were attacked by units of the Blue 1st and 2d Divisions. One Red bombardment and one attack group were not on their airdromes during the Blue attacks but severe losses were inflicted upon the other Red units. Blue attack and bombardment units suffered considerable losses from Red pursuit during these operations and will not be in condition to operate again before 6:00 AM, 28 March.

b. The Blue 2d Pursuit Group intercepted a Red attack group in Area B, and the 3d Pursuit Group intercepted a Red bombardment group in Area C during the morning, 27 March. Both Red groups were disorganized, but the two Blue pursuit groups suffered such damage that they will be unable to operate before dawn, 28 March.

c. The Blue 1st Pursuit Group engaged in no combats during the morning of 27 March, and is on its airdromes on the alert for interception missions.

3. SPECIAL SITUATION, CONTINUED.--Beginning at 2:00 PM, 27 March, a series of messages were received by Brigadier General A, Air Defense Commander, who was in Defense Headquarters, together with his staff, at Montgomery, Alabama. The following are extracts from those messages:

(1) "2:00 PM. Red bombardment group, javelin formation, 12,000 feet over Eutaw (Ala.) course 105°.

B, Observer
11th Obs. Group."

(2) "2:08 PM. Square B 85. 36 Red bombers, 15,000 feet, flying 105°.

Observer,
Alarm Net."

(3) "2:13 PM. Square A 78. 36 Red bombers, 15,000 feet, flying 105°.

Observer,
Alarm Net."

(4) "2:16 PM. Square A 72. 36 Red bombers 15,000 feet, leaving square. Course 105°.

Observer,
Alarm Net."

(5) "2:20 PM. Square A 60. 36 Red bombers, 15,000 feet. Course 45°.

Observer,
Alarm Net."

(6) "2:23 PM. Square B 49. 36 Red bombers leaving square, 15,000 feet, course 45°.

Observer,
Alarm Net."

(7) "2:27 PM. Square B 39. 36 Red bombers, 15,000 feet, changed course from 45° to 120°.

Observer,
Alarm Net."

(8) "2:30 PM. Square B 32. 36 Red bombers 15,000 feet, course 120°.

Observer,
Alarm Net."

(9) "2:33 PM. Square B 25. 36 Red bombers, 15,000 feet, course 120°.

Observer,
Alarm Net."

(10) "2:36 PM. Square A 18. 36 Red bombers, 15,000 feet, course 120°.

Observer,
Alarm Net."

(11) "2:39 PM. Square A 11. 36 Red bombers, 15,000 feet, course 120°.

Observer,
Alarm Net."

4. REQUIREMENT.--a. Give in detail the actions taken and orders issued by Brigadier General "A", Air Defense Commander, between 2:00 and 2:40 PM, 27 March. Cover only such acts and orders as apply to the denial of hostile aerial operations and, if an interception is ordered, his reasons for issuing the order at that particular time.

b. If, in your opinion, interception should occur prior to the receipt of any particular message given in Special Situation (paragraph 3), disregard messages received later.

c. If combat between Blue and Red occurs, a final message should be included showing time, place and Red unit attacked. A form for this message follows:

__________ (Time) __________ (Blue Unit) Attacking __________ (Red Unit)

Over __________ (Square or place) at __________ (Altitude) __________ (Signature)

NOTE 1.--For this problem, Air Defense Headquarters will prepare and broadcast all necessary orders and instructions to the 1st Pursuit Group.

NOTE 2.--All pursuit airplanes have two-way radio sets.

NOTE 3.--A constant speed of 210 miles per hour will be assumed for pursuit units employed in this problem.

NOTE 4.--A delay of 5 minutes must ensue between the order for "Stations" and the execution of the Order, "Take off".

NOTE 5.--The weather is clear.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

MAP PROBLEM NO. 1

SECTION II

A SOLUTION

5. A SOLUTION.--a. Upon receiving the radio message at 2:00 PM, Brigadier General "A" directed S-2 to note the position upon the map and to be prepared to plot the course of the Red bombardment group. He directed that all further messages relating to the Red force be relayed to Colonel "B", commanding 1st Pursuit Group, at his operations office. Then with S-2 and S-3, he awaited further reports of the hostile force.

b. At 2:08 PM, he directed Colonel "B" to order the 1st Pursuit Group to "Stations".

c. At 2:13 PM, he issued the following order to Colonel "B":

"Take off immediately. Intercept and attack the Red bombardment group reported over Square A 78."

He then directed that all further information relating to the Red group be radioed without delay to the 1st Pursuit Group in the air.

d. His reasons for ordering off the 1st Pursuit Group at 2:13 PM are as follows:

(1) The Red bombardment group has been flying a straight course aimed directly at Montgomery for 13 minutes. Apparently its objective is either the city of Montgomery or the airdromes of the 1st Pursuit Group.

(2) The enemy is well within intercepting range and the limit of delay for a timely interception has arrived.

e. The following messages pertaining to the interception of the Red force were received:

(1) "2:28 PM. Red bombardment formation sighted three miles south Thorsby. Will attack at once.

'B'
Colonel, 1st Pursuit Group."

(2) "2:30 PM. Blue pursuit attacking Red Bombardment formation two miles east Clanton.

Observer,
Alarm Net."

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73	74	75	76	77	78
67	68	69	70	71	72
61	62	63	64	65	66
55	56	57	58	59	60
49	50	51	52	53	54
43	44	45	46	47	48
37	38	39	40	41	42
31	32	33	34	35	36
25	26	27	28	29	30
19	20	21	22	23	24

32°

87°

85	86	87	88	89	9
79	80	81	82	83	8
73	74	75	76	77	7
67	68	69	70	71	7
61	62	63	64	65	6
55	56	57	58	59	6
49	50	51	52	53	5
43	44	45	46	47	4
37	38	39	40	41	4
31	32	33	34	35	3
25	26	27	28	29	3
19	20	21	22	23	2

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85	86	87	88	89	90	85	86	87	88	89	90
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67	68	69	70	71	72	67	68	69	70	71	72
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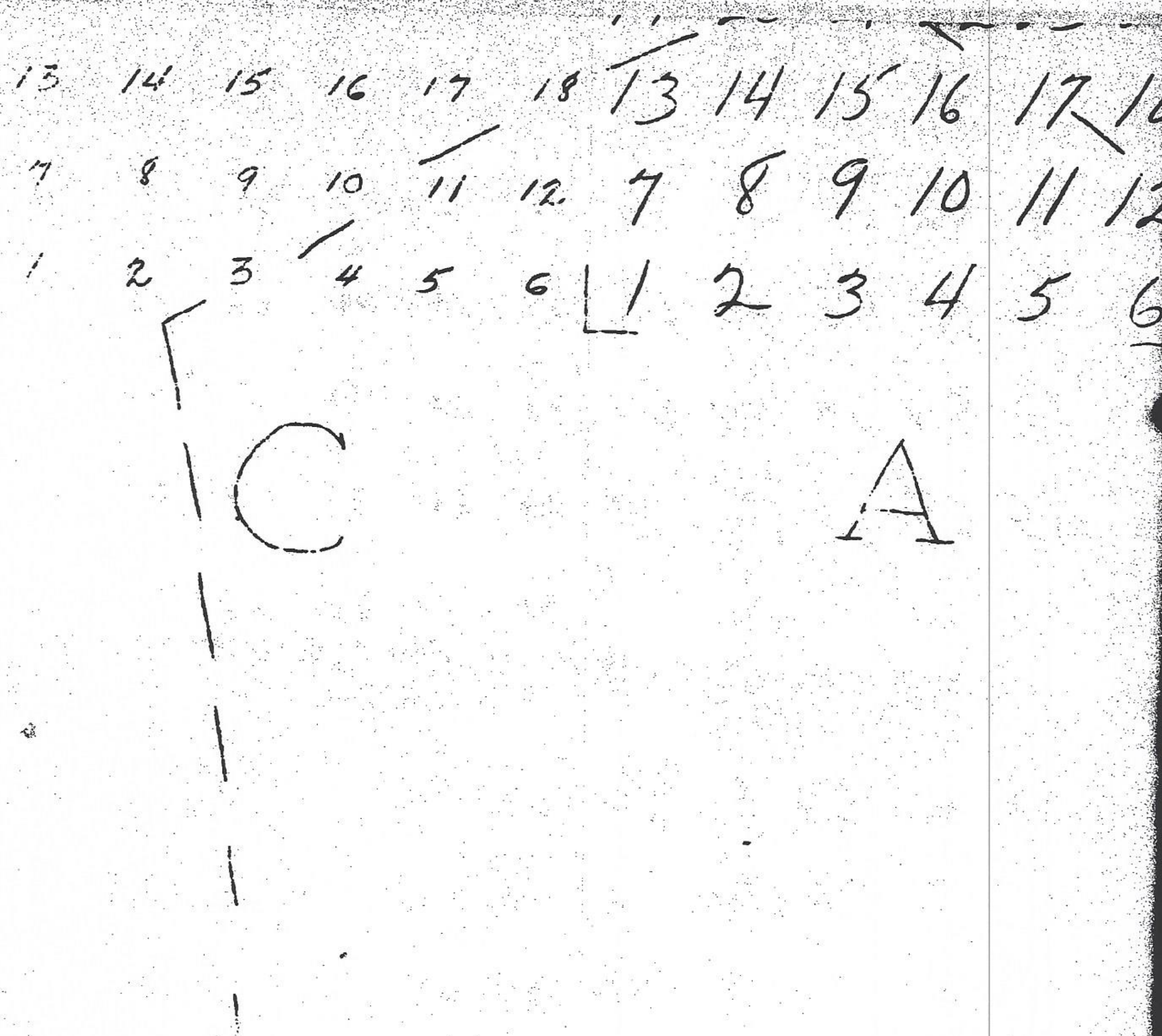
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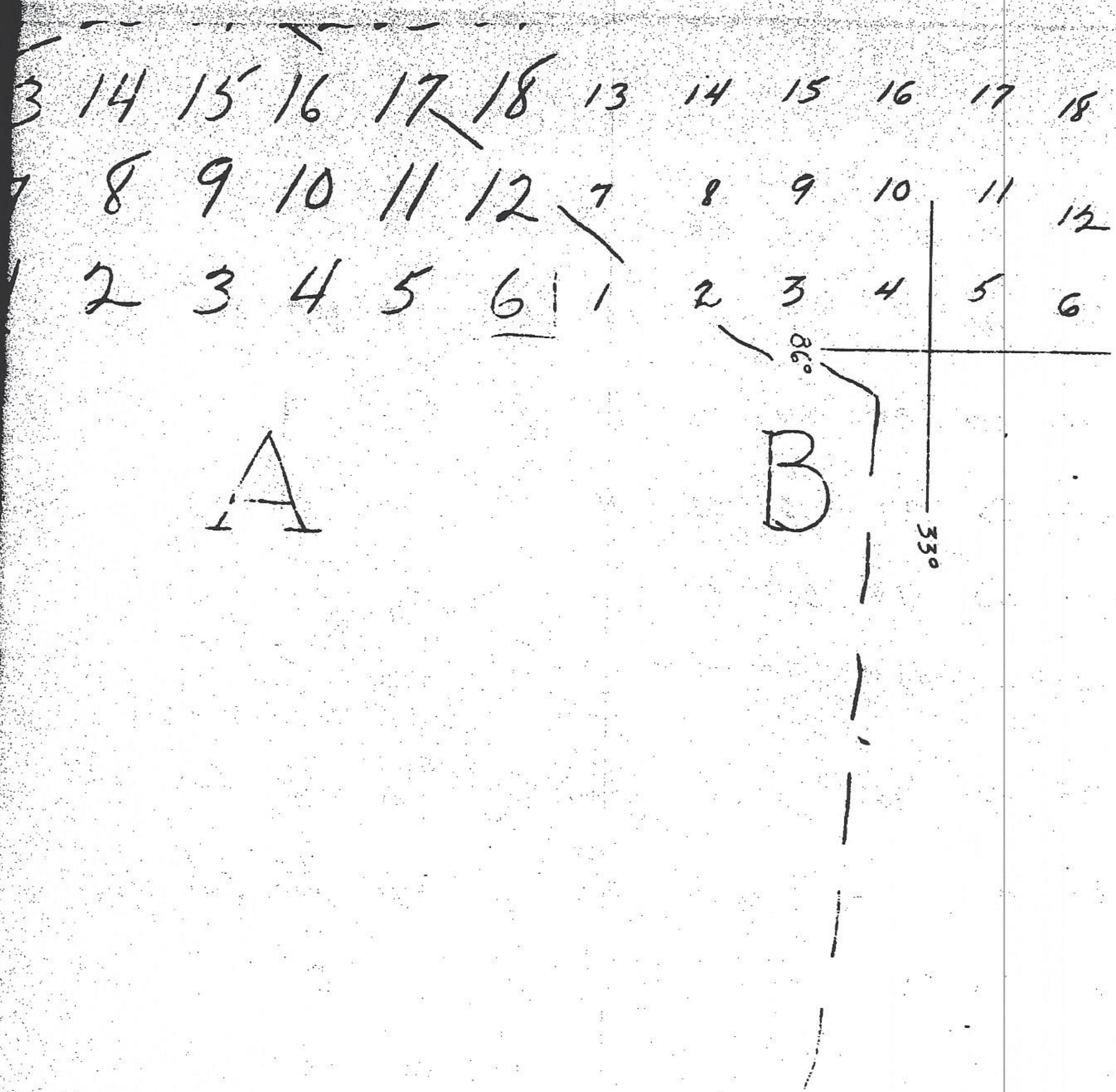
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THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

MAP PROBLEM NO. 1

SECTION III

COMMENTS ON SOLUTIONS

	Paragraph
Comments.	7

7. COMMENTS.--The following comments apply to solutions as indicated by reference numbers on the students' papers:

1. Order for stations or take-off issued too early.
2. Reasons not clear or not stated.
3. The special situation (see Map Problem) indicates that the Reds have no more than one group available for offensive missions.
4. Blue pursuit would be unavailable for a period of an hour or more after take-off even if this Red bombardment formation is not attacked. No cut.
5. One pursuit squadron is not considered an effective force for opposing one bombardment group.
6. This unit is not included in the Blue Air Force.
7. All messages pertaining to the position of the hostile force should be promptly transmitted to pursuit.
8. The entire 1st Pursuit Group (Blue) is on the alert.
9. The Blue 1st Pursuit Group should have been employed for this interception.
10. Reasons for orders not given in sufficient detail.
11. Interception was not made far enough out.
12. Navigational directions are not transmitted to pursuit when the "Square" method is employed.
13. Interception made too far away for time allowed.

14. The 2d and 3d Pursuit Groups (Blue) could not operate before dawn, 28 March. R.T.P.

15. An excellent solution.

16. Paper poorly written or arrangement poor.

17. To much repetition or unnecessary detail.

P-2
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THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 1

HISTORY AND DEVELOPMENT OF PURSUIT AVIATION

Prior to the beginning of the World War, aviation was regarded as an expensive and unreliable means of reconnaissance. Only a few enthusiasts were bold enough to predict its importance in future warfare.

General Von Hoeppner in Germany's War in the Air, describes the attitude of the German High Command as follows:

> "In general, not any too much expectation was put on aerial reconnaissance. It was frequently estimated that after a few weeks none of our own and no hostile planes would be seen in the heavens. The performance of the fliers who reported comprehensive information daily, surprised the High Command, who doubted the details that were given and were willing to wait for confirmation through some other medium of intelligence."

In England, the situation was slightly different. In 1912, General Sir James Grierson said, "Warfare will be impossible unless we have the mastery of the air." A few aviation enthusiasts in England foresaw the necessity for aerial combat, for in February, 1914, the War Office published a memorandum prescribing flight tests and minimum performance characteristics for both single and two-seater fighting type airplanes. Thus the English accomplished a great deal of experimental work on the production of fighters before the other nations involved in the war were convinced of the necessity for providing this type.

In this country, machine guns were fired from airplanes as early as 1911, but aside from demonstrating the possibility of aerial gunnery, very little was done toward developing the airplane as a weapon of warfare. After the withdrawal of the 1st Aero Squadron from Mexico in August, 1916, the Commanding Officer, Captain B. D. Foulois, made lengthy recommendations for technical improvements in the equipment to increase its effectiveness for reconnaissance, but omitted any reference to developing equipment suitable for combat. This omission is most noteworthy because the World War had been in progress for two years at that time and because it is well known that General Foulois was an ardent believer in military aviation.

England, France, and Germany employed airplanes for reconnaissance from the very beginning of military operations. The reports of aerial observers, however, were seldom accepted as trustworthy unless verified by other means. In fact, the value of aerial observation was not fully appreciated until it was realized that a hostile aerial observer could reveal a plan of battle as certainly as the most accomplished secret agent. With this appreciation of the danger of hostile aerial

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observation, there arose the demand for denying hostile observation--which could be accomplished only by aerial combat.

A number of aerial combats occurred during August, September and October, 1914. These combats were the result of the aggressiveness of individuals rather than of military design, however. Pilots and observers equipped themselves with pistols and rifles for the purpose of destroying an enemy rather than for the denial of hostile observation. High commands on both sides published orders directing their pilots to avoid combat in order to obtain the desired information.

The combat reported on October 16, 1914, more than two months after the beginning of war, reveals the first deliberate design to deny freedom of action to hostile aircraft. The report follows:

> "A Royal Flying Corps airman on a fast scouting monoplane, and carrying two rifles, gave chase to a hostile machine but lost sight of the enemy in clouds. Then a German Otto bi-plane came on the scene, a slow 'bus' but one having the engine behind and, therefore, if well armed, a formidable opponent. The English pilot obtained a position behind the enemy and when within sixty yards, he fired one rifle without result. His superior speed taking him ahead, he turned and again getting astern, emptied his magazine at the German, who began to descend. Then the Englishman stopped his engine and began a down glide while reloading. Unfortunately the magazine jammed, but he managed to insert four cartridges and to fire them at his opponent who disappeared into a bank of clouds. The Englishman followed but never saw him again."

Although his enemy escaped in convenient cloud banks, this report indicates that the English pilot "on a fast scouting monoplane and carrying two rifles" was undoubtedly employed for the purpose of destroying hostile aircraft in flight. Here also the beginning of aerial combat tactics is revealed in the statements that "The English pilot obtained a position behind the enemy", and "he turned and again getting astern * * *." Thus aerial combat born of the twin requirements (1) maintenance of aerial observation of the enemy, and (2) denial of hostile observation of friendly forces, came to be accepted by military authorities as not only possible, but extremely desirable.

Due to the fact that the English began developing work upon fighter types earlier than the other nations, they were better prepared for aerial combat in the early days of the war than were the other powers. Among the early fighters employed by the British were the Maurice-Farman pusher, the Morane bi-place, the BE-2-C, the Martinsyde scout, the RE-5, the Bristol scout, the DeHaviland 2, the Vickers Gunbus (FB-5) and the FE-2 type.

It was found early in the war that the tractor type airplane did not permit of fire to the front due to the position of the propeller. For this reason efforts were directed toward developing the pusher type with the gunner mounted in the nose and equipped with a flexible gun. The FB-5 was an outstanding example of this type airplane and it was extremely successful in aerial combat in 1915.

From 1912--1914 French development had been directed toward producing high speed airplanes, thus a number of monoplane types were produced and were available at the beginning of the World War. Generally, however, these French monoplanes had undesirable flying characteristics and were not sufficiently strong to withstand the required maneuvers.

In Germany the authorities had restricted themselves almost wholly to the development of airplanes suitable for reconnaissance only. When the necessity for air combat was realized in the early fall of 1914, intense efforts were directed toward producing suitable types. In 1915 the Albatross, Aviatik, and the Fokker monoplane were produced. The performance of these airplanes was comparable to that of the French and British, but they were not produced in sufficient numbers to overcome the initial advantage of the English.

The production of specialized fighter airplanes led to a new problem; that of organizing and employing them correctly. Since these fighters were to support friendly observation and deny hostile observation, it was at first assumed that a number of fighters should be included in each observation unit as large as a squadron. It was assumed that the organization of composite tactical units would lead to close cooperation between personnel and would insure the presence of fighters in areas where reconnaissance was to be conducted. However, this composite organization was found to have a very serious weakness, after a few months' trial. This weakness resulted from the fact that the fighters, dispersed in small numbers among numerous units, were never sufficiently concentrated to achieve the effect of mass action. It was also found that the few fighters assigned to an observation squadron were unable to provide close support when opposed by hostile fighting craft. The British were the first to react to this deficiency, and during the fall of 1915 and winter of 1915--16, the Royal Flying Corps organized and equipped a number of fighter squadrons.

On the German side of the lines single-seater fighters were assigned to armies and groups of armies, in small numbers, for the purpose of defending both the observation airplanes assigned to those armies and the ground troops from the attacks of hostile aircraft.

Naturally, it was impossible to obtain an effective concentration of German pursuit at any given point under this system; in fact, the pursuit assigned to German armies was practically valueless. During the spring of 1916, Boelcke conceived the idea of organizing independent pursuit units for action wherever required in order to gain control of the air. The first squadron was organized and employed at Verdun. The Battle of the Somme, June 30--November 30, 1916, resulted in a complete change in combat tactics and organization in both the German and British Air Forces. From July 1 to September 15, the Royal Flying Corps so dominated the air that German observation was unable to operate effectively while British observation was able to carry out practically every mission assigned, with little fear of hostile aircraft. One report submitted by General Trenchard stated that for an entire week only fourteen hostile machines were observed crossing the line of trenches in the Fourth Army Area, while 2000 to 3000 British machines had crossed the same lines during that period. General Von Hoeppner states, with regard to this situation, that "One of the chief mistakes in the early weeks of the Battle of the Somme was the failure to recognize the importance of the single-seater pursuit planes. The Second Army (German) had few single-seaters and made poor use of what they had." In another place, General Von Hoeppner says, "Our pursuit and combat squadrons * * * were not suitable for this sort of mission and after having met with heavy losses they were obliged to give it up * * * *. All this was due, doubtless, to our numerical inferiority and to errors in employment which cannot be denied."

The situation on the Somme became so desperate that on September 15, Boelcke was transferred from Verdun to the Somme. On the morning of the 16th he conducted his first patrol with five airplanes and succeeded in shooting down five British planes with no loss to his own unit. During the next two months, Boelcke, personally, accounted for 20 British airplanes while his squadron was credited with a total of approximately 80 victories. The British had been operating with small units which broke up upon the first contract with the enemy. Boelcke, on the other hand, used larger units, which maintained some degree of cohesion throughout a fight. He was the first to teach teamwork in mass action. Although Boelcke was killed in an aerial collision in October, 1916, his teachings, of the value of concerted action by large numbers and of close teamwork by the individuals of small formations, were perpetuated by his former pilots and combat students. Among these former students was Richtofen, who became famous during 1917 and the early part of 1918 for his employment of large numbers of pursuit planes in concerted action. Richtofen's circus was transferred frequently wherever intense aerial activities developed and was never defeated as a unit. On the other hand, it inflicted serious losses on Allied aviation in every combat.

Summarizing methods of employment for pursuit during the World War, we have, in the beginning, the individual pilot acting largely upon his own initiative with regard to the area of his operations. Later, two-man teams developed where the lower man acted as "bait" for a more skilful team-mate flying above him.

During the Battle of the Somme, offensive patrols were conducted by designating definite patrol lines to be flown by small formations of pursuit. The Close Support method was also used during this battle. The Close Support method for employing pursuit required pursuit to fly in close proximity to the supported force. This deprived pursuit of initiative and aggressiveness.

In 1917 the barrage patrol was developed and used extensively. This form of employment was designed to deny certain areas to hostile aircraft. It consisted of the organization of a large pursuit force which conducted regular patrols through a great range of altitude around and over designated areas. The barrage patrol resulted in a tremendous expenditure of pursuit effort and did not accomplish satisfactory results. The exhaustion of pursuit from barrage patrols led to an attempt to conserve pursuit effort by employing fighting airplanes upon the alert. Under the alert method of employment, a few pursuit planes were sent into the air while the majority were retained upon the ground, the plan being that the planes on the ground would join those in the air after combat developed. Since pursuit combat is a matter of a very few minutes, it was found that the planes on the ground were usually unable to join those in the air before the combat was terminated.

Still another method of employing pursuit was developed for special situations. In the defense of London and of Paris, pursuit was kept on the ground until alerted by reports from distant observation outposts. It then took the air for the purpose of intercepting and attacking hostile aircraft approaching the defended area. This alert pursuit, once in the air, was unable to receive any further information of the enemy until the British employed radio receiving sets in pursuit airplanes in the spring of 1918. The majority of interceptions attempted by alert pursuit were unsuccessful, due to this lack of further information of the enemy.

Thus, at the close of the World War, there still existed a great deal of doubt and uncertainty with regard to sound methods of employment of pursuit. A few principles, however, had been developed and were generally recognized as such. Among these principles were:

(1) The value of surprise.

(2) The desirability of teamwork in aerial combat.

(3) The necessity for mass in order to obtain decisive results.

(4) The necessity for developing the most improved equipment for pursuit use.

(5) The necessity for employing highly specialized pilots in pursuit work.

(6) The necessity for providing interceptor pursuit after leaving the ground, with information of the enemy.

Accepting these principles as being sound, we are in position then to develop technique and tactics for the employment of modern pursuit.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 2

THE PURSUIT AIRPLANE

The relationship between equipment and tactics in pursuit work is very close. While almost any type airplane may be employed for other missions, only a highly specialized type can accomplish the pursuit mission with any degree of effectiveness. This requirement for a high degree of specialization is not generally appreciated even among air men. It is usually assumed that a pursuit airplane is effective for any combat mission. However, the field of pursuit employment embraces such a wide range of altitude and so many varying combat conditions that it is impossible for any one type plane and power plant to perform satisfactorily under all probable conditions.

Pursuit has the mission of forcing combat, in the air, upon all types of hostile aircraft. Thus it may engage hostile pursuit, bombardment, attack or observation aviation. Opposed to hostile pursuit, the maximum of maneuverability may be required. Opposed to bombardment, maneuverability is not important, but speed, climb and the ability to fire accurately at long ranges are of great importance. Bombardment may be expected to fly at medium to high altitudes, so that climb and ceiling become important characteristics of pursuit designed to combat hostile bombardment. Attack aviation may be expected to present the same tactical problem as bombardment except that attack will operate at very low altitudes, thus eliminating the requirements for rapid climb and high ceilings. Corps observation will usually operate at medium to low altitudes and will employ maneuverable airplanes of medium speed. Here the requirement for high speed and rapid climb for pursuit may be eliminated. However, Army and G.H.Q. Observation may operate at extremely high altitudes, as will most photographic airplanes, and opposing pursuit must have a fast rate of climb and high ceiling in order to deny freedom of action to these types.

During the World War, it was found, from experience, that certain types of pursuit planes had superior performance at definite altitudes. In the Royal Flying Corps, the Camel possessed the greatest degree of maneuverability at low altitudes, while the SE-5 was most maneuverable at high altitude. The British took advantage of these differing characteristics by arranging masses of airplanes with the Camels at low and intermediate altitude, while the SE-5s flew in support at high altitude. The Spad was able to withstand fast pull-out after a long dive; so pilots cruised the Spad at high altitude and invariably attacked from a fast dive. The Fokker D VII was able to stand on its tail for an appreciable time. German pilots took advantage of this characteristic by attacking from below the enemy.

After the end of the World War, the supercharger for both radial and Vee type engines was developed. Until about 1931, it was generally believed that the supercharger rendered a single type of pursuit

P-3
36-270
4-13-36
dw

airplane effective for combat at all altitudes. With the development of high-speed, monoplane bombers, however, it became apparent that a single type of pursuit airplane could not accomplish both the mission of engaging bombardment at high altitudes and a maneuverable type of observation or pursuit at low or intermediate altitude.

An attempt to provide a dual-purpose airplane, capable of performing both of these missions resulted in the production of the P-26 type. The P-26 is a low wing monoplane, super-charged, and has a minimum load factor of 12-1. Flown as an experimental type in 1931, it developed higher speed than any other military airplane in the world. Its climb and service ceiling were satisfactory. A quantity contract was negotiated for a large number of P-26's but the Martin type of bomber was developed before the first P-26's were constructed. This bomber, with a very low load-factor, developed speed approximating that of the P-26, thereby rendering the P-26 obsolescent. About 1933, the British produced two bi-planes, the Hawker and the Fairey, which had considerably greater speed than the P-26 and which were far more maneuverable. Other foreign countries followed suit, so that by the time the P-26 was produced in service quantities, it was exceeded in its performance by numerous foreign pursuit airplanes and was not comparable to the newer types of bombardment and attack airplanes.

Most textbooks include a table of characteristics for pursuit airplanes, arranged in the order of their relative importance. Such tables mean absolutely nothing unless the mission, for which the pursuit plane is designed, is stated. It must be realized today that no one type of airplane can conceivably accomplish all the missions pertaining to pursuit aviation. Generally speaking, these missions fall within two fields, interception and close combat. For Air Force missions, that is, for missions where the Air Force is acting independently of surface forces, interceptions will constitute the great majority of pursuit missions. We hear a great deal of discussion of a first phase in future warfare. It is assumed that during the first phase long-range aerial operations, directed against hostile airdromes and industrial centers, will be engaged in by all the combatant powers concerned in the war. Since these operations will be conducted at such ranges as to make it impossible for pursuit to take part, the only role open to pursuit will be to deny the penetration of hostile aircraft over friendly defended areas. Visualizing conditions which will probably exist in such a situation, we may assume that hostile bombardment will constitute the principal threat to those defended areas. However, it will be desirable to deny penetration of those areas to hostile observation also, since the enemy will depend upon his observation for the location of targets for his bombardment.

Both hostile bombardment and long-range observation will undoubtedly fly high and will employ airplanes with considerable speed at altitude. Therefore, defending pursuit must be equipped with an airplane capable of climbing at the greatest possible rate and also capable of attaining considerable speed in level flight at altitude. Since neither of the types of enemy aircraft named may be expected to engage in violent maneuvers, but rather will depend upon speed or numbers for defense, the interceptor pursuit type need not possess a high degree of maneuverability. For the same reason the strength factor of the interceptor type may be lowered far below that required for fighter type pursuit planes. The English realized that an interceptor would not be required to engage in violent acrobatics several years ago, and as a result, the English have produced bi-planes with a load-factor of 8 to 1 which out-perform our present monoplane interceptors. With regard to the question of lowering the load-factor, an argument is sometimes advanced that an airplane incapable of being put through the most violent acrobatics will operate to lower the morale of the pilots. Such an argument is absurd, because we have today numerous types of bombardment, attack, observation, and transport planes which cannot withstand violent acrobatics. It should be clearly understood by everyone concerned, that the interceptor pursuit type is a very highly specialized type of airplane, designed for a particular purpose, just as the latest bombardment plane is designed for a particular purpose; that the interceptor type has distinct limitations which must be respected.

The armament for the interceptor should also be highly specialized. It should be equipped with long-range weapons, capable of attaining considerable accuracy beyond the ranges of the defensive weapons carried by bombardment. For this purpose, a cannon of not less than 20-mm caliber should be installed as the principal weapon. Supplementing this cannon, there may be one or more machine guns of .30 or .50 caliber for employment at close ranges in special situations. As additional armament, the interceptor should carry, normally, a minimum of 10 time-fuzed bombs of not more than 15 pounds weight each. Accurate sights should be developed and installed for the cannon and machine guns at all ranges and for dropping the time-fuzed bombs with the desired degree of accuracy.

It is apparent that this interceptor type airplane will not be suitable for engaging in combat with a highly maneuverable type hostile plane. For close combat between rival pursuit forces, or between pursuit and maneuverable observation types, an airplane with a high strength factor and the maximum degree of maneuverability is required. Also, the requirements for armament are different from that of the interceptor type. Large caliber guns, accurate at long ranges are not required here. The majority of the combats in this field will be of the maneuvering or dog-fight type. The objective of the pursuit pilot will be to kill the opposing pilot, and for this purpose a small caliber machine gun, with a high rate of fire, is the most desirable weapon. This field of pursuit employment relates almost altogether to the support of ground army operations. We have prepared elaborate plans for the mobilization and employment of four field armies. We actually have a sufficient number of National Guard and Reserve observation squadrons for assignment to these armies and to the corps composing the armies, but we do not have a single pursuit unit or pursuit airplane designed for the purpose of supporting army and corps observation or for denying hostile observation of the same types. The trend of development in pursuit equipment is more and more toward the highly specialized interceptor type, so that in the future it may be expected that the interceptor and the close combat types will be even less interchangeable than they are today.

In view of the high degree of specialization attained in airplanes of all other classes of aviation, the time has arrived when the all-purpose pursuit plane must be abandoned in favor of, at least, two types of highly specialized pursuit airplanes. To continue further the attempt to perform all pursuit missions with the single type airplane will inevitably result in the complete failure of pursuit to perform any of its assigned missions in a satisfactory manner.

At this point it is appropriate to discuss the two-seater pursuit plane and the proposed multi-seater battle-plane. A number of efforts have been made to produce a two-seater pursuit plane which would be more effective than a single-seater. Supporting this project there have been advanced any number of arguments in favor of the two-seater. To mention a few, there is the argument that only the two-seater can break off combat; that only a two-seater can engage hostile formations from level flight; that the two-seater is more effective offensively, because it is not required to maneuver for defense; that the two-seater can be built with much greater range than the single-seater; that it can be used as a reserve for the single-seater; that it can provide special support for other classes of friendly aviation.

Without going into a lengthy discussion of all these arguments, it should suffice to point out that the two-seater is a compromise, -- an attempt to combine in one vehicle both offensive and defensive fire power. Experience has taught that any compromise between two or more conflicting characteristics results in the production of an article which is less effective in one or both fields of activity than is an article designed exclusively for the highest degree of effectiveness in one field only. The two-seater pursuit plane is no exception to this invariable rule.

With regard to the proposed multi-seater battle-plane, we are told by the advocates of this project that the battle-plane can be built with considerably greater fire power, and with superior performance, than a contemporary bombardment plane. We also hear plans for maintaining a number of these battle-planes in the air over a defended area for the purpose of preventing the penetration of hostile bombardment. We hear other plans for assembling these battle-planes in aerial fleets with a view to laying alongside the hostile bombardment fleet or battle-plane fleet, and engaging in fleet actions with heavy guns. It has been found impracticable, if not impossible, to construct a battle-plane with superior fire power and greatly superior performance over contemporary bombardment types. The design of such a plane would be such as to permit its ready use as a bomber. The removal of the heavy armament and the substitution of bombs for this armament and ammunition load, would produce a bomber with flying characteristics greatly superior to those of any other bomber. Assuming that the enemy was able to do the same thing,-- both sides would then have bombers which could not be forced into combat by hostile battle-planes. The proposal to maintain the fixed defense of battle-planes constantly in the air, over defended areas, is most impracticable. It was proven on many occasions during the World War that airplanes could not maintain a fixed defense and that any attempt to do so invariably resulted in exhaustion of the defensive forces with little or no damage to the enemy. Such an attempt would also violate the principle of economy for these battle-planes would necessarily be expensive and a large number would be required to maintain a considerable force in the air at all times. The employment of expensive defensive planes is inconsistent with one of the principles which should govern pursuit development, that is, the principle of cheapness. The pursuit plane should be <u>cheap</u>, both in regard to monetary cost and to time and labor required to construct it. The loss of two or three pursuit planes in exchange for one hostile bombardment plane should result in an economic advantage for the defense.

The idea of aerial fleet actions is interesting, although there does not seem to be any prospect for such actions in the near future. The construction and employment of a very expensive airplane for the purpose of engaging in battle with a hostile airplane, of the same general type, cannot be justified from either a military or an economic viewpoint. An aerial combat, considered independently, with no relation to the action of other air or surface forces, has no point.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
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Course: PURSUIT AVIATION

CONFERENCE NO. 3

THE ROLE OF DEFENSIVE PURSUIT

The designation, "Defensive Pursuit", as used in the title of this conference is a striking illustration of the inaptness of accepted military terminology when applied to air force operations. Since ancient days, any military force or effort which was not designed primarily for the invasion of hostile territory has been classed as "Defensive".

In accordance with this ancient definition, Interceptor Pursuit is a defensive force, although its tactical employment is wholly offensive. In fact, it would be extremely difficult to conceive of a force more offensive in its characteristics. With no necessity for providing for its security in the air or for holding out a reserve, it is planned to employ every individual in the Interceptor unit for the offensive function of forcing combat upon hostile aircraft.

It is true that the anticipated combat between Interceptors and hostile aircraft will begin over territory friendly to the Interceptors but it may often occur that this combat will terminate over hostile terrain. However, it is not necessary to argue about the name applied to this class of pursuit since the role of the Interceptor is so clearly defined as to readily distinguish it as a highly specialized class of aviation with distinctive equipment, tactics and technique.

Any study of this subject must necessarily consist of the consideration of the numerous factors which pertain to or determine the role of Interceptor Pursuit. Of these factors, the following will be considered in this conference:

(1) Function
(2) Physical location of units
(3) Organization
(4) Equipment
(5) Factors pertaining to the interception of hostile aircraft.

The correct statement of the function of Interceptor Pursuit is, "To intercept and attack designated hostile aircraft flying within its range of action". It is unnecessary to include "the disorganization and destruction of hostile formations" as they are tactical objectives whose attainment is contingent upon interception and attack.

This functional definition is often incorrectly stated as follows, "To defend a designated point or area from the attack of hostile aircraft". In this case, the action of the pursuit force is confined to a limited area and to the strictly defensive attitude of attacking only the hostile aircraft which may attempt to penetrate into the designated area. The computation of the numbers of aircraft required for the local defense of a large number of areas, such as might be anticipated in a defense of the United States, results in a total far beyond the possibility of attainment.

P-3
36-270
4-13-36
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The location of Interceptor Pursuit units depends upon the geographical location of the two hostile states.

Thus, in a war between states having a common boundary, we should expect to find Interceptor units located in a narrow belt paralleling the border and at sufficient distance from the border to accommodate the time and space factors required for timely interceptions. The distance between the border and pursuit airdromes depends upon the characteristics of hostile and friendly aircraft and the efficiency of the ground aircraft reporting service. In no case should pursuit airdromes be so advanced as to require the approach to the interception to be made from the rear of the hostile force.

The approach from the rear requires the interception to be made at a rate which represents the difference in speed between hostile and friendly airplanes--never a very large figure. On the other hand, the approach from the front of the hostile force permits an interception speed equal to the sum of the speeds of the two forces. While an exact head-on interception may never be attained in practice, the objective of the intercepting unit should be to make every approach at an angle less than 90° to the enemy's line of flight.

This principle pertaining to the angle of approach was not appreciated in the past and is not generally understood today. We still hear statements that it is necessary for pursuit to fly at altitudes thousands of feet above the enemy formation so that it can decrease the time required for closing to combat by diving down from the rear. A moment's reflection should convince anyone that superior altitude is not required if the approach is conducted from the front and the final closing to combat is effected by properly timed turns made in the vicinity of the hostile force.

Another error of the past was the belief that interceptions were facilitated by advancing pursuit airdromes as near the border or front lines as possible. The fallacy of this theory was clearly demonstrated in the 1931 Royal Air Force Maneuvers. The objective of these maneuvers was to test England's air defense installations, with particular attention to the ability of pursuit to make interceptions.

For this purpose, English pursuit units were located on airdromes beginning at the coast and extending back to the vicinity of London. The "enemy", represented by bombardment units of several types, was required to cross the coastline on each attempt at a penetration. The fastest pursuit squadron, equipped with the high speed, 215 miles per hour, Hawker "Fury" was based within sight of the Channel while slower units were on airdromes deeper in the interior. During maneuvers lasting two weeks, the squadron of Furies was unable to make a single interception before the "enemy" arrived over his target. One hostile Hawker "Hart" squadron, high speed 176 miles per hour, was intercepted before reaching its target on every attempt by units equipped with pursuit planes having a margin of speed less than ten miles per hour. All pursuit units operated under identical conditions except the one factor--distance of airdrome from the border or front.

This experience not only proved the fallacy of the theory that Interceptor pursuit units should be pushed as far forward as possible but provided the R.A.F. with valuable data for determining the depth of space required for timely interceptions. This space factor will be discussed in detail later.

In a war such as might require the defense of the United States against an enemy making his major effort by the attack of powerful air forces, we may expect those forces to be concentrated in a definite area. This area may be as large as some of the European states but it will certainly have definite limits which can be established. The difficulties of maintaining communications, of command and supply will force considerable concentration of the hostile air force. The necessity for concentrating hostile effort upon a designated area of limited extent in order to obtain decisive results quickly will insure against the dispersion of hostile units over such distances as thousands of miles along our borders and seacoasts. There will be no point in having some hostile units in range of our Pacific or Gulf Coasts if the objective of the enemy is to paralyze the industrial area of the northeastern states.

This concentration of hostile forces will result in "fixing" the enemy so that his air attacks must come from one general direction. The proper location of our Interceptor pursuit units in such a situation will be in a narrow zone as far forward (toward the enemy's concentration area) as is consistent with the requirements for timely interceptions. This airdrome zone will be established so as to intersect the nearest line of approach from the hostile concentration area to our most vital area within his range. It will extend to each side of the nearest line of approach as far as the number of our Interceptor units will provide effective concentrations or geographical features will permit.

The location of Interceptor units in this manner will permit pursuit to concentrate in effective numbers against hostile formations and will enable all available interceptor units to expend their maximum combat effort. The employment of Interceptors for the local defense of numerous areas will result in such dispersion of forces that an effective force will not be available in any single area. On any given day, the majority of the Interceptor units defending local areas will have no combats while a few units will be required to engage greatly superior hostile forces.

The employment of Interceptors for local defense may be justified under certain special conditions. For instance, a state having but one vital area should certainly concentrate all of its Interceptor pursuit for the defense of that area. Thus, during the World War, German air attacks upon the British Isles were concentrated upon London and its suburbs.

In some situations it may be expected that the major hostile air effort will be directed against our airdrome areas, initially at least. The location of Interceptor units so as to facilitate the interception of hostile aircraft engaged upon missions against our airdromes will afford our Interceptors the opportunity for expending maximum combat effort. In any case the Air Force is of such vital importance and is so vulnerable when immobile upon the ground, that the minimum requirements for its security will necessitate the assignment of an Interceptor force of considerable size to that mission alone.

The organization of our present G.H.Q. Air Force is such that Interceptor pursuit is provided in numbers barely sufficient for satisfying normal requirements for the security of Air Force airdrome areas. No pursuit airplanes or units are provided for the general defense against hostile air attacks or for army cooperation. This deficiency in pursuit will have no ill effect if our counter-offensive force is successful in quickly destroying the hostile striking force and if there is no necessity for army operations. However, our counter-offensive may not be wholly successful or the army may be required to take the field. In either case a period of at least eighteen months will be required to correct the initial deficiency in Pursuit Interceptor and Fighter type airplanes.

At present, three pursuit groups composed of three squadrons each are authorized. An additional squadron for each group is assigned to school duty. For an emergency, we have available nine squadrons of pursuit.

Two pursuit groups are now assigned to Composite Wings, one each of bombardment and attack. Experience indicates that the assignment of pursuit to composite organizations provides no tactical advantage but results in such dispersion of pursuit forces that effective concentrations at any one point are impossible. However, the composite organization in peacetime does afford pursuit opportunities for training with other classes of aviation.

In order to obtain the maximum degree of effectiveness, it is believed that Pursuit should be organized in Wings consisting of three groups and groups of four squadrons.

The three group wing provides sufficient strength for long continued operations and, on occasion permits pursuit to engage in sustained action with large hostile concentrations by successive group attacks. The effect of engaging the enemy with fresh groups at intervals of fifteen to twenty minutes cannot fail to be cumulative. The enemy will be less able to resist each new attack.

For routine "Alert" duty, the Wing of three groups permits a rotation of groups on the alert so that repairs to equipment can be made while flying personnel are resting.

The Group of four squadrons provides sufficient mass strength for the majority of operations. Fewer squadrons would result in ineffective combats and more than four squadrons would result in providing an unwieldly group which could not find space for the engagement of all of its units. The four-squadron group also facilitates the simultaneous attack on hostile formations from four directions.

Experience indicates that the squadron of eighteen airplanes in three flights is the most effective squadron organization.

The subject of equipment was discussed in the conference on the Pursuit Airplane. However, for the sake of emphasis, the principal points with regard to the equipment provided for Interceptor units will be repeated here.

The Interceptor airplane must be able to climb at the maximum rate. It should possess high speed at altitude. It need not be highly maneuverable and does not require a factor of safety which will enable it to withstand violent acrobatics at high speed. Its armament should include a light gun of 20 to 25 mm. capable of delivering accurate fire at long ranges. Pending the development of such a gun, .50 caliber machine guns should be installed. The Interceptor should carry and be able to drop accurately a minimum of ten 15-lb. time-fuzed bombs. A load of twenty 10-lb. bombs would be preferable. The accessories to flight such as radio and oxygen should be provided. Above all, the Interceptor should be a small airplane, presenting the minimum target area to hostile gunners, and should be economical in construction, both with regard to cost in money and in time required for production.

The principal factors pertaining to the interception of hostile aircraft are:

(1) Time
(2) Space
(3) Information of the enemy
(4) Visibility.

The time factor affects the problem of interception at the following points:

(1) Time required for the collection and transmission of information of the enemy and for issuing orders.

(2) Time required for defending forces to leave the ground after receiving the order.

(3) Time required to fly from defending airdromes to the point of interception.

The time values for the first and second operations may be reduced to minimum figures by intensive training of personnel and proper organization. During the Fort Knox Maneuvers, 1933, the average time required for the receipt of information of the enemy was more than two minutes while the time required for the take-off varied from five to fifteen minutes. For the Miami Maneuvers, 1935, messages pertaining to hostile aircraft were assumed but the average time required for the take-off was about four and one-half minutes. A comparison of these time values with those attained by units of the Royal Air Force shows how much can be accomplished by training and proper organization. An M.I.D. report on British Air Maneuvers, 1931, states, "Raid warnings are received and plotted in the operations headquarters within half a minute. The interceptor squadron would receive its instructions within three minutes of a raid's crossing the coast and would be in the air within five minutes". A careful study must be made of all the operations required for an interception with a view to reducing to the minimum the time required for each phase.

The time required to fly from Interceptor airdromes to the point of interception will vary with each mission. It is determined by such factors as the route, speed and altitude of the enemy, the location of pursuit airdromes with reference to the route of the enemy, and the speed and rate of climb of Interceptor airplanes. The reduction of this time value to the minimum consistent for effective operations results in the conservation of pursuit effort.

The space factor is the principal consideration in determining the location of Interceptor airdromes. The space factor is determined, principally, by the extent and effectiveness of the ground aircraft reporting service or alert net. Sufficient space must be provided between the Interceptor airdromes and the farthest points where information of the enemy will originate to accommodate all the time values necessary to making a timely interception of hostile aircraft.

The calculation of the space required for an interception is comparatively simple when all the time values, the performance of hostile and friendly aircraft, and the meaning of timely interception are known.

For illustration, assume that Interceptor pursuit desires to make a head-on interception of a hostile force flying 210 miles per hour, at 15,000 feet on a course which will bring it over the vicinity of the pursuit airdrome. The Interceptor can climb to 15,000 feet at an average rate of 2,500 feet per minute with a forward speed of 120 miles per hour. In order to comply with the tactical requirements for a timely interception pursuit must make contact with the enemy 6 minutes before he arrives over the pursuit airdrome. Assuming that the total time required for receiving information of the enemy, issuing the order to take off and for taking off is 6 minutes, we set up the following equation in order to determine the time required for pursuit to arrive at 15,000 feet: $6 \text{ plus } \frac{15,000}{2,500} =$ 12 minutes. Of this 12 minutes, 6 minutes apply to the space factor, for during 6 minutes pursuit moves forward at the rate of 120 miles per hour. During the entire period of 12 minutes, however, the hostile force is approaching at the rate of 210 miles per hour. Therefore, in order to arrive at the value of the entire space factor, the following equation is set up: $\left(12 \times \frac{210}{60}\right) + \left(\frac{15,000}{2,500} \times \frac{120}{60}\right) = 54$ miles. Pursuit can make interception under the conditions named if information of the enemy originates 54 miles from the pursuit airdrome. However, the interception will occur but 12 miles from the pursuit airdrome which does not satisfy the requirement of 6 minutes for a timely interception. Six minutes at the enemy's speed is equivalent to 21 miles of distance. Assuming that the Interceptor's high speed in level flight at 15,000 feet is 270 miles per hour, it is apparent that pursuit must fly 2 minutes at this speed in order to make the interception 21 miles out instead of 12 miles; an increase of 9 miles in the space factor. During these 2 minutes the enemy will cover 7 miles. The total space requirement then is (54 + 9 + 7) = 70 miles.

An analysis of the assumptions made for the purpose of illustrating the method for calculating the space factor leads to the conclusion that several values may be altered by the training of personnel, and the production of improved equipment. Five minutes instead of six should suffice for the collection of information and the take-off of an Interceptor unit. The high speed of the Interceptor at 15,000 feet should be 300 miles per hour and can be obtained easily if a specialized Interceptor type rather than an all-purpose type of pursuit airplane is provided. The average rate of climb to 15,000 feet can be increased to 3,000 feet or more per minute by the same means. The Interceptor airdromes will usually be located well in advance of possible targets for hostile bombardment so that there will be no necessity for making interception 21 miles in advance of those airdromes.

In conclusion of this discussion of the space factor, it is believed that well-trained Interceptor units equipped with properly designed airplanes and operating on information furnished by an efficient aircraft reporting service can make interceptions consistently when located fifty miles from the outermost observation posts. Poorly trained units equipped with all-purpose airplanes may require one hundred miles for any interception and will be unable to make interceptions consistently.

There are two agencies which are capable of collecting and transmitting information of the enemy, aerial observation and the ground Aircraft Reporting Service.

Aerial observation has the advantages that it may extend out farther and that it will usually provide more accurate details regarding the type, altitude, and course of the enemy. However, if aerial observation alone is relied upon for information of the enemy, it is obvious that a prohibitive number of observation planes will have to be employed in order to thoroughly patrol all areas over which the enemy may approach. Aerial observation is of little value for such work at night and the transmission of its reports over considerable distances is uncertain and unreliable.

The ground aircraft reporting service, sometimes called the Antiaircraft Warning Service, the Alert Net, the Alarm Net, and Aircraft Warning Service, is able to operate both night and day and in any weather when flight is possible. Information from its observation posts is transmitted by wire and is not subject to interference by the enemy.

It is known that England, Germany, France and Italy have developed effective aircraft reporting services covering all areas where possible targets for hostile air attack are located. Of all these systems, the details of the English net are best known. However, the principal features of all the systems are similar. These features are:

(1) The immediate location and report of hostile aircraft entering the net.

(2) Periodic reports of the enemy by successive posts at frequent intervals.

(3) The use of pursuit and ground guns to deny freedom of action to the enemy as well as for his destruction.

(4) The coordination of all defense installations, both active and passive, under one authority.

The aircraft reporting service is the basis of successful air defense. Its value is stressed in a volume entitled, "Air Defense", by General E. B. Ashmore. It is necessary even if nothing but purely passive defense measures are contemplated and it is absolutely essential for the successful execution of offensive measures. Since it is the basic requirement for air defense, the organization and equipment of this service should receive priority over all other defense measures, even the production of Interceptor type airplanes.

The details of the organization of the aircraft reporting service and the technique involved in its operation will be discussed in the next conference.

Visibility affects the problem of making an Interception less today than during the World War. Due to the fact that the progress of the enemy force will be reported at frequent intervals to the Interceptors by radio, it is believed that pursuit can make interception under any condition of visibility when the enemy will attempt to operate in force. Single airplanes may use clouds to shield their approach to a target and to escape attack but large formations will have great difficulty in locating and attacking a target except by flying in the clear for a considerable period of time.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 4

THE AIRCRAFT WARNING SERVICE AND ALERT NET

The use of the word "Warning" in the name of this service does not convey the proper meaning. While the service may warn, its basic requirement is to report accurate details with regard to hostile aircraft flying over the net. The use of the word "Reporting" in the title would convey a far more adequate idea of the requirements of this service than does "Warning".

The German Alert Net is somewhat different in organization to that of any other nation. Exposed to possible air attack from every direction, German air defense is planned on a series of concentric circles with defense areas prescribed by radial lines radiating out from the center of the country to the borders.

Observation--Listening posts are located at distances of 15 to 20 kilometers apart over the whole country. From 5 to 10 posts are connected by direct telephone lines to an Information Center while two or three Information Centers are connected to a central Intelligence Center. This organization completes the net for a single defense area or sector, but all defense areas are connected directly with General Defense Headquarters. General Headquarters directs the application of both active and passive defense measures in threatened areas.

The English net covers the industrial regions and centers of population of England and Scotland only. Its general shape is irregular but more rectangular than round. Its organization is practically the same as the German, except that more Observation-Listening posts are connected to each Information Center, about 15 to each Center. The Intelligence Centers are eliminated by connecting Information Centers directly to Defense Headquarters. There are no clearly defined defense areas since the objective seems to be the interception and destruction of hostile air forces penetrating toward the interior. As in Germany, air defense headquarters is charged with the conduct of all defensive operations, both active and passive. It controls all the agencies of defense, including Interceptor pursuit, ground guns, the Aircraft Reporting Service, searchlights, balloon nets, artificial smoke devices, the darkening of areas, the cessation of industrial activity in threatened areas, and the operations of fire, sanitary, and chemical squads.

Personnel for the operation of the Aircraft Reporting Service belong to the Observers Corps, a reserve military organization. The policy of assigning members of this corps to duties in the vicinity of their homes is strictly adhered to in so far as is possible.

A number of units of the Observers Corps are called to active duty annually for the operation of the net and other defensive measures

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km

during the period devoted to Royal Air Force Maneuvers.

The Italian Aircraft Reporting Service is organized to cover all the provinces of Italy except the marshy maritime provinces which contain no profitable targets for hostile air attack. Italian defensive measures are so detailed as to include the sandbagging of monuments and the protection of valuable works of art.

The latest reports on the French air defense system indicate that six areas only have been designated for defense and that the defense of each area will be an independent operation. This plan must result in the division and dispersion of available equipment and may lead to ineffective defense in one or all areas. Certainly an offensive effort can be prepared which will be able to overwhelm the defense in a single area. No recent reports on French defense measures are available and it is probable that this plan for the local defense of six independent areas has been abandoned in favor of a centralized system which will be able to concentrate defensive effort to resist hostile air invasion rather than to attempt to defend designated points from hostile air attack.

Explain the diagrammatic representation of an Aircraft Reporting Service for the Montgomery Area.

Explain the square and the round interception maps, pointing out the differences in technique involved in the operation of the two methods.

Explain the organization and technique for making night interceptions.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1934--1935

Course: ANTIAIRCRAFT ARTILLERY

CONFERENCE NO. 4.

The following extracts from an address by Major General William F. Hase, Chief of Coast Artillery, at the Army War College, September 14, 1934, is published for the information of the personnel on duty at the Air Corps Tactical School:

ANTIAIRCRAFT ARTILLERY
ORGANIZATION AND DEVELOPMENT

Your Commandant has given me the opportunity to speak to you this morning about antiaircraft artillery, an arm which came into being in the World War, and the organization and development of which have become a main concern of the Coast Artillery Corps.

In General Orders No. 22 of December 31, 1927, the War Department prescribed the mission and composition of the Coast Artillery as follows:

"The missions of the Coast Artillery are the attack of enemy naval vessels by means of artillery fire and submarine mines, and the attack of enemy aircraft by means of fire from the ground.

The Coast Artillery includes all harbor-defense artillery, all railway artillery, all antiaircraft artillery, and all tractor-drawn artillery especially assigned for coast defense purposes. In addition, it includes such sound-ranging units as are needed in performance of its missions."

In Coast Artillery Field Manual, Volume II, Antiaircraft Artillery, Part One, Tactics, a more specific statement of the general mission of attack of enemy aircraft by means of fire from the ground is made in the following words:

1. The mission of antiaircraft artillery is to provide a local defense for ground forces and important establishments against enemy aviation both by day and by night.

a. The mission of antiaircraft artillery guns is to attack high-flying hostile aircraft, particularly bombardment and observation aviation. They will, however, attack all types

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of aircraft that may enter their effective zone of fire in accordance with the tactical demands of the moment.

b. The mission of antiaircraft artillery machine guns is to attack low-flying hostile aircraft, particularly low-flying attack, bombardment and observation aviation. They will, however, attack all types of hostile aircraft within their effective zone of action.

c. The mission of antiaircraft artillery searchlights is to discover and illuminate hostile aircraft operating at night, in order that antiaircraft artillery may fire upon them effectively. A secondary mission is to illuminate hostile aircraft so that they may be attacked by friendly aviation.

d. The mission of the sound locators is to discover the presence and determine the position of hostile aircraft operating at night or during periods of poor visibility. They usually operate in conjunction with the searchlights but during periods of poor visibility, they may operate directly in conjunction with antiaircraft artillery guns in the execution of barrage missions."

To carry out its mission of firing on moving targets, naval and air, the Coast Artillery has been organized into harbor defense, railway, tractor drawn, and antiaircraft artillery regiments.

The Regular Army antiaircraft artillery component of the Coast Artillery consists of four active and twenty inactive regiments in continental United States, a regiment in Hawaii, a regiment in the Philippines, and two regiments in Panama; the latter have the dual role of manning both seacoast and antiaircraft artillery. In continental United States about one-third of our total Coast Artillery regimental strength is in antiaircraft artillery, the four antiaircraft regiments having an enlisted strength of 1572. In ten active Antiaircraft Artillery regiments of the National Guard we have an enlisted strength of 5427, giving us in the continental United States approximately 7000 antiaircraft artillerymen. In Hawaii our antiaircraft artillery strength is 1044, in the Philippines 552, and in Panama the two dual purpose Coast Artillery regiments have a strength of 2260.

In considering the development of means of combating aerial attack by fire from the ground, a brief review of aerial bombardment and attack, and of measures taken in defense during the World War is worthwhile. Little or no attention has been given to defense against air attacks and no special armament or fire control apparatus was on hand. Intelligence systems had been predicated on pre World War operations and gave scant attention to means of ascertaining enemy approach by air.

In England, the 1915 Zeppelin attacks forced the development of a country-wide observation and intelligence system, the purpose of which was originally to direct defending planes against the attackers before the latter could reach their objectives. It was soon apparent that sufficient planes to cover the country could not be obtained and maintained ready for immediate use, and the use of guns, machine guns, and searchlights was begun. The main defense was around London.

In France, an antiaircraft artillery defense for Paris had come into being by September, 1915. The intelligence net for this defense included stations about fifty miles from the city. Antiaircraft gun batteries were with the armies, but no special antiaircraft machine gun organizations were formed. Gun batteries and searchlights were equipped with machine guns for protection against aerial attack.

In Germany, antiaircraft artillery was emplaced for the protection of the Rhine cities and bridges, for installations on the Belgian coast, and for Heliogoland, and a comprehensive intelligence and observation system was developed. It is understood that over 500 antiaircraft guns were emplaced in Germany and on the Coast, and that about 1100 were in use with armies in the field in the fall of 1918.

Although war-time antiaircraft artillery was comparatively crude as compared to the modern high muzzle velocity, quick-firing guns, the number of planes actually brought down by antiaircraft fire was great, the French reporting 220 in 1918 and the British 176 in the same year. The progress in this arm is indicated by the fact that in 1916, the British Antiaircraft artillery had brought down only 50 planes and the French, 60.

When we entered the war, having no antiaircraft artillery material, we used for this purpose, French 75-mm. guns on auto trailers, French Hotchkiss machine guns, and searchlights varying in diameter from 26" to 60". By the end of the war, the antiaircraft service had expanded to a force of 5,000 artillerymen for the antiaircraft guns, 4500 infantrymen for the antiaircraft machine guns, and 2500 engineers for the antiaircraft searchlights. Twelve of our gun batteries saw active service at the front, manning materiel loaned by the French. Two Antiaircraft machine-gun battalions and five Antiaircraft searchlight batteries saw active service. From July to November of 1918, our antiaircraft guns were credited with bringing down seventeen hostile planes with an expenditure of 10,273 rounds of ammunition, an average of about 605 shots per plane. In target practice fired at a towed sleeve, our 3" guns average 9 per cent of hits; the .50 caliber M. Gs average 2.3 per cent. But since we are not able in target practice to simulate conditions which will be met in service firings, we don't draw conclusions from reports of target practice as to the probability of hitting under battle conditions.

Under the provisions of the National Defense Act of 1920, the Coast Artillery Corps took over the operation and development of antiaircraft artillery, including guns, machine guns, and searchlights. Although muzzle velocities and rates of fire for antiaircraft guns were considerably increased and fuzes improved during the war, the materiel on hand was generally unsatisfactory having in large part been improvised to meet the needs of the moment. Furthermore, little materiel was on hand and before supplying even any part of our needs, research and development were required, in order that we might produce weapons capable of attacking effectively the higher speed planes. The Coast Artillery, Ordnance Department, the Corps of Engineers and the Air Corps joined forces in an intensive development campaign, which I believe has given us the best antiaircraft artillery armament and accessories in the world. We are greatly indebted to the Air Corps for their cooperation in towing targets for the extensive firings that have been conducted incident to this development. We have quality but not quantity, and while our research and development must be pursued constantly, I believe that our major aim must be production. Unlike mobile artillery designed to fire on terrestrial targets, we inherited no large store of guns like the 75's and 155's which we have in considerable quantities. A similar shortage exists in our antiaircraft artillery ammunition and in our fire control apparatus. Our store of searchlights for antiaircraft artillery is entirely insufficient. 108 are under manufacture out of P.W.A. funds. These are earmarked for Panama, (79), and Hawaii (29).

In July, 1933, an attempt was made to secure from Public Works Administration an allotment of $33,325,000.00 to provide modern antiaircraft artillery equipment for the 8 regular army regiments, 7 of the 10 National Guard regiments and the 20 inactive Regular regiments.

If this sum had been made available, we would be well on our way toward complete equipment for 35 regiments out of the 80 to be mobilized under the latest Mobilization Plan.

It has been estimated that at least two years would elapse before the materiel could be manufactured.

Manufacturing capacity for this type of equipment is decidedly limited.

Our best antiaircraft gun, left from the World War, was the 3-inch AA gun, M-1918, on a trailer mount. The present standard weapon is the 3-inch AA gun M-3 on the mobile mount M-2. During the past year, we have had test firings with our latest, greatly improved unit, the 3-inch AA gun T8 on the single axle mount, T3. At the conclusion of my talk I shall show some slides which will indicate to you the transition from the war-time gun and mount to our most up-to-date unit. Our earlier development aims were to secure relatively short times of flight by using high muzzle velocities, long ranges, accuracy, and high rates of fire, and in securing them, our guns had to be given considerable weight, were complex, and lacked mobility. In our latest gun and mount, using the single axle, we have greatly reduced the weight, we have a simple and mobile unit, the load is much lower, and we have not sacrificed range, accuracy, or rate of fire. The cost of production will be reduced and the towing vehicle can be much lighter and less expensive. For the same expenditure we shall be able to get many more units than we could get if production were continued of the present standard gun and mount.

The latest 3-inch antiaircraft gun can deliver fire at the rate of 25 shots per minute at ranges as follows:

With the mechanical fuze, vertically at 27,900 feet and horizontally at 10,550 yards.

With the present efficient powder train fuze, vertically at 25,650 feet and horizontally at 7,550 yards.

High explosive shell is the normal war ammunition, but shrapnel is used in training and target practices, on account of peace-time restrictions in firing high explosive ammunition. Fragments of the bursting shell cover a volume of about 137,000 cubic yards, known as the danger volume. The shape and extent of the volume covered will be shown later by a slide.

Several years ago, the Ordnance built two 105-mm guns on fixed mounts. When they were proof-fired at Aberdeen they were not entirely satisfactory, but a later model which was proof-fired in 1930 gave satisfactory results. With P.W.A. funds, we have under manufacture 12 of the later units. These are earmarked for the protection of vital installations in the Canal Zone. We do not contemplate going on with further production of these guns, which, although firing a far heavier projectile at a much greater range (vertical 36,900 feet) and of much greater danger volume on explosion, have certain disadvantages, one of which is a much lower rate of fire.*

Antiaircraft machine guns have been much improved as to rate of fire and stability. We have adopted as our standard the caliber .50 Browning machine gun with a maximum vertical range of 15,000 feet and a maximum horizontal range of 7500 yards, and capable of firing short bursts at the rate of 600 shots per minute. The maximum effective range of this machine gun is now about 2000 yards due to the limitations in the tracer, which has been found to be the only practicable means of controlling fire. Many sights have been experimented with, but due to the many changing variables affecting the range setting and lead, when firing at a fast moving, low flying, and rapidly maneuvering plane, none has been found satisfactory, whereas trained personnel can obtain astonishing results relying on the modern, efficient tracer. Our greatest troubles in the development of this weapon have been securing a stable but sufficiently flexible mount, hiding the flash, and perfecting the tracer. Details of this gun and mount will be shown by slide.

We feel the need for a fast firing antiaircraft weapon intermediate between the caliber .50 machine gun and the 3-inch gun, and are endeavoring to develop a gun with substantially the following characteristics:

Size and weight: about a 37-mm caliber gun on a light but stable mount permitting a quick going into action from traveling position.

Ammunition: a high explosive shell, a little over a pound in weight, with a super-sensitive percussion fuze (it may be necessary to have a time fuze).

Rate of fire and muzzle velocity: about 80 rounds per minute and with a high muzzle velocity. It is possible that we may have to accept a considerably smaller muzzle velocity than the 3,000 feet per second, which was hoped for. Development of such a gun, mount, and ammunition has not progressed rapidly. During the past year we have investigated the merits of certain European-manufactured automatic weapons which approximate our requirements in certain respects. We bought one Solothurn gun from a Swiss manufacturer and recently tested it. It has a range of about 5500 yards and fires a projectile weighing only

* <u>Note</u>: There will be a lower rate of fire per gun per minute but not necessarily a lower volume of burst per minute.

about a third of a pound and having a supersensitive fuze. Existing tracer ammunition for this gun limits the effective range to 1500 yards for firing against airplanes. It did not answer our requirements.

Our latest searchlights are 60-inch in diameter and are operated with power generated by the engine of the carrying truck. The standard antiaircraft searchlight of 800,000,000 candle power can illuminate bombardment planes at over 12,000 yards under favorable weather conditions. Fog and mist radically cut down the practicable illuminating distances. Our most important recent development in searchlights has been the adoption of a metal instead of a glass mirror, thereby cutting down cost and time of production of making a more rugged and durable unit.

For locating planes at night, enabling searchlights to pick them up, we use a system of listening outposts, where specially trained soldiers report, by telephone from distant stations, the approximate locations of planes and directions of approach. We also use instruments known as "sound locators" which can pick up sounds at distances far beyond the capabilities of the human ear. Two listeners at this instrument keep it trained in elevation and azimuth, an experienced operator applies a correction for sound lag, which is very appreciable at the distances at which we work. By means of electric coordination, through an instrument known as the comparator, the searchlight and the sound locator are kept synchronized.

"The "sound locator" has many inherent disadvantages, among them being the interference caused by sounds other than the one sought, thus forcing location of the locator at quiet and secluded places often hard to obtain, and the difficulties of accurate correction for sound lag. The true correction is really arrived at by successive approximations, as it is a function of the distance to the plane, and is affected by wind and the configuration of the terrain when the plane is low.

We need and shall continue to improve our "sound locators" but we are now engaged in research in a more promising field, utilizing instruments which can indicate the position of an object at great distances, employing a medium other than sound. Such instruments are not only inherently more accurate than sound locators, but are also necessary as the muffling of airplane engines and stream lining of planes are perfected.

Probably the greatest progress in antiaircraft artillery has been attained in our fire control instruments. We have efficient, although expensive, height finders and a remarkable instrument known as the "director", be means of which we follow the target and determine proper deflections or leads, both lateral and vertical, and a proper elevation and fuze setting, the altitude obtained from the height finder being kept set on the director. By means of an electric transmission system and "match-the pointer" devices on the guns and at the fuze setters, we keep the guns continuously trained on the target and have the fuzes always properly set. Prediction is carried on mechanically within the instrument and since observation, mechanical prediction, electric transmission and setting are practically instantaneous, there is no "dead time" and firing data never go stale. Our latest "director" allows for a parallax correction, permitting its location as far away from the guns as 1000 yards. This feature is of particular value because it permits proper protection or concealment of this nerve center of the battery.

The "director" and the stereoscopic height finder are both expensive and complex, and would be difficult of quantity production in time of war. The present director with its data transmission system costs about $30,000.00; the height finder $13,000.00. Our present effort is to develop simpler and less expensive apparatus. The two station altimeter system of height finding is simple and efficient, but has serious defects when used under conditions when many planes are in the air. Development of a short base two-station system of height finding is being investigated and holds much promise; the shorter the base, the less will be the likelihood of the two stations getting on different planes. In investigating the development of the "director", we have taken up the matter of using a similar instrument for seacoast artillery firing on naval targets. A much less complicated instrument has been developed and is being manufactured for the solution of this simpler two-dimensional problem. It is hoped that this work will bring forth methods and means which will make possible simplifications in the existing antiaircraft director. Slides will be shown later which will give an idea of the appearance of these directors.

I recently had the privilege of hearing an account of a World tour, undertaken by an American citizen who is an expert on antiaircraft artillery materiel, in order to investigate the status of antiaircraft fire control and accessories in foreign countries. Most countries in Europe and Asia are keenly alive to the need of antiaircraft artillery and practically all have provided themselves with guns and auxiliaries of varying amounts, and are striving to solve to their satisfaction the fire control problem. No country, however, appears to have the full team of requisites, namely: good guns and searchlights and satisfactory fire control equipment; some are fairly well provided with some of these elements but are altogether lacking in others. I am firmly convinced that we are well ahead of any foreign country in our general antiaircraft artillery development and that with our new gun, our improved searchlight, and our efficient fire control apparatus, both existing and forthcoming, we are in a condition where production of a considerable part of our antiaircraft artillery requisites is not only warranted, but is most necessary on account of slowness of production and our shortages. If our development were not so far advanced, dictat tates of economy and efficiency would properly warrant delay in production, but I think we are now fully justified in producing enough new armament, ammunition, and accessories to equip all our Regular and National Guard Antiaircraft Artillery completely, keeping the older materiel to start the equipping of the many units which must be formed in case of war, and for the expansion of the skeletonized existing Regular Army regiments.

Under the Four Army Plan we shall have eighty regiments of antiaircraft artillery. We need many more, but our materiel shortage, particularly in guns, fire control, and searchlights, is such that there is no present possibility of building up to a greater strength for many years. Therefore it would be idle to list greater numbers in a plan which must be based on possibilities. The true answer is a liberal annual production of antiaircraft materiel, so that we can approach within a reasonable time our true tactical requirements of materiel.

The guns and fire control equipment for a regiment of antiaircraft artillery can be procured at a cost of approximately $1,000,000. The motor transportation required by a mobile regiment totals approximately $800,000.00. The antiaircraft regiment to which I have referred is a mobile organization consisting of two main combat units, the gun battalion and the machine gun battalion. The gun battalion includes three batteries, each of four guns, with four antiaircraft machine guns for local protection, and one searchlight battery of three platoons, each platoon containing five light sections. Each searchlight will be protected by an antiaircraft machine gun. The machine gun battalion consists of four machine gun batteries, each of twelve machine guns, grouped four to the platoon. The guns are 3-inch in caliber, the machine guns are caliber .50, and the searchlights are of 60-inch diameter.

The details of the regiment, including necessary headquarters and service units, will be shown in a slide.

The regiment is a Corps unit. No antiaircraft artillery is assigned basically to the division, but in case of detached missions, requiring the use of antiaircraft by the division, it could be attached in suitable amount to the division from the corps regiment. I believe, however, that the one regiment with the corps provides a very small reservoir of antiaircraft artillery with the corps, and that it will be necessary to increase the antiaircraft artillery with the corps to two regiments, at least if the present regiment remains at its existing strength, which includes only three gun batteries.

Army antiaircraft artillery consists of a brigade of two or three regiments.

Antiaircraft artillery is provided for Hawaii, the Canal Zone, and in the Philippines according to needs and the normal regimental organization set-up plays no part in establishing the area defense required. In harbor defenses, fixed antiaircraft guns are emplaced at sites best located for covering the seacoast artillery installations from aerial attack. These harbor defenses, usually being in the immediate vicinity of important port areas, will generally provide an important nucleus of antiaircraft guns from which can be built up additional defense required, using mobile guns of regiments available in the area or by providing additional fixed batteries. Personnel for antiaircraft guns in the harbor defense are included in harbor defense troops, and are not supplied by the antiaircraft regiments. All Coast Artillerymen, manning seacoast artillery and its auxiliaries, have additional training in some of the components of antiaircraft artillery.

Our training, particularly our antiaircraft artillery target practices, has afforded great opportunity for research leading to most of our developments. Our training activities are diverse. Our long range antiaircraft machine gun firing is usually carried on at the longer tracer ranges, since troops of other arms often have an opportunity for practice at the shorter ranges. We have found that by painting bullets we have a good means of identifying the particular gun making hits. For our gun target practices, we have developed camera spotting which shows accurately the position of the burst with relation to the target, and therefore permits it to remedy intelligently fuze and armament imperfections. By means of tactical exercises, such as the recent Joint Antiaircraft-Air Corps Exercises held at Fort Knox, Kentucky, we examine our capabilities, and seek means of overcoming our deficiencies. In this exercise we made a very satisfactory test of comprehensive antiaircraft intelligence system. Probably the only real weakness revealed in our antiaircraft artillery defense, was in the "sound locators", particularly when functioning against gliding and muffled planes and when endeavoring to locate bombers when other aircraft were in the air. In previous exercises to test material and technique, such as the searchlight exercises at Fort Humphreys in 1931, the sound locators and searchlights functioned so efficiently, that it was made apparent that in air attacks, more thought was required as to the tactics of approach and greater effort to muffle engines was required. Knowing of the progress in these matters made by the Air Corps before the Knox exercises and recognizing certain inherent defects in sound locating, which I have already referred to, we have initiated development work with the view to perfecting an apparatus which employs a medium other than sound. We hope for rapid progress in this development, and that we may have an opportunity to test it in exercises with the Air Corps within the next two or three years.

I have described briefly our regimental organization, and details of it will be shown by a slide. I am not sure that the grouping into two main units, a gun battalion and a machine gun battalion, is the ideal one. I do not believe that we have the requisite armament in the regiment. With the advent of a speedier bomber, there is a need to extend the gun defense. For requisite concentration of fire, we can not extend this defense any farther than is permitted by the 6000 yards considered as the maximum distance between batteries. I believe the solution to this question is to add another gun battery to the regiment. With respect to antiaircraft machine guns, I believe all concerned are in agreement that a machine gun battery should contain more than the 12 machine guns now allotted, and that there should be a machine gun with every searchlight. When the question of an additional gun battery and more machine guns is settled, definite action can be taken to the proper organization of the regiment. My belief is that we shall eventually favor a regiment of two like battalions, each battalion containing gun, machine gun, and searchlight batteries. The regimental organization, being based on defense requisites for corps or army installations in one case, and Zone of the Interior installations in the other case, must be somewhat of a compromise as to the suitable components in guns and machine guns. Meanwhile, since our materiel deficiencies are so great, I see no gain in altering, at present, our regimental organization. Our present regiments provide a suitable reservoir of armament and accessories which can be built up as funds become available, necessary regrouping to be undertaken when we approach completion of our armament supply under the present set-up.

Antiaircraft artillery is a requisite of every modern army. It is an efficient and economical means of providing vital installations with a sure, and always present, defense against aerial attack. We can no more afford to commit our air forces to defense than we can afford to tie up our fleet for coast defense. We are glad to note that our friends in the Air Corps share this opinion with us, and are giving us material assistance in carrying on our development work. We have a continuing task in development, so that we may keep abreast of improved means of aerial attack. We cannot insure destruction of all of our adversaries, but we can drive hostile bombers to heights where bombing is more difficult, we can break up hostile aerial formations, and we can cause such losses that the aerial attacker will suffer a tremendous handicap if he is then forced to meet our own air forces.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 1

HISTORY AND DEVELOPMENT OF PURSUIT AVIATION

Prior to the beginning of the World War, aviation was regarded as an expensive and unreliable means of reconnaissance. Only a few enthusiasts were bold enough to predict its importance in future warfare.

General Von Hoeppner in Germany's War in the Air, describes the attitude of the German High Command as follows:

> "In general, not any too much expectation was put on aerial reconnaissance. It was frequently estimated that after a few weeks none of our own and no hostile planes would be seen in the heavens. The performance of the fliers who reported comprehensive information daily, surprised the High Command, who doubted the details that were given and were willing to wait for confirmation through some other medium of intelligence."

In England, the situation was slightly different. In 1912, General Sir James Grierson said, "Warfare will be impossible unless we have the mastery of the air." A few aviation enthusiasts in England foresaw the necessity for aerial combat, for in February, 1914, the War Office published a memorandum prescribing flight tests and minimum performance characteristics for both single and two-seater fighting type airplanes. Thus the English accomplished a great deal of experimental work on the production of fighters before the other nations involved in the war were convinced of the necessity for providing this type.

In this country, machine guns were fired from airplanes as early as 1911, but aside from demonstrating the possibility of aerial gunnery, very little was done toward developing the airplane as a weapon of warfare. After the withdrawal of the 1st Aero Squadron from Mexico in August, 1916, the Commanding Officer, Captain B. D. Foulois, made lengthy recommendations for technical improvements in the equipment to increase its effectiveness for reconnaissance, but omitted any reference to developing equipment suitable for combat. This omission is most noteworthy because the World War had been in progress for two years at that time and because it is well known that General Foulois was an ardent believer in military aviation.

England, France, and Germany employed airplanes for reconnaissance from the very beginning of military operations. The reports of aerial observers, however, were seldom accepted as trustworthy unless verified by other means. In fact, the value of aerial observation was not fully appreciated until it was realized that a hostile aerial observer could reveal a plan of battle as certainly as the most accomplished secret agent. With this appreciation of the danger of hostile aerial observation, there arose the demand for denying hostile observation--which could be accomplished only by aerial combat.

A number of aerial combats occurred during August, September and October, 1914. These combats were the result of the aggressiveness of individuals rather than of military design, however. Pilots and observers equipped themselves with pistols and rifles for the purpose of destroying an enemy rather than for the denial of hostile observation. High commands on both sides published orders directing their pilots to avoid combat in order to obtain the desired information.

The combat reported on October 16, 1914, more than two months after the beginning of war, reveals the first deliberate design to deny freedom of action to hostile aircraft. The report follows:

> "A Royal Flying Corps airman on a fast scouting monoplane, and carrying two rifles, gave chase to a hostile machine but lost sight of the enemy in clouds. Then a German Otto bi-plane came on the scene, a slow 'bus' but one having the engine behind and, therefore, if well armed, a formidable opponent. The English pilot obtained a position behind the enemy and when within sixty yards, he fired one rifle without result. His superior speed taking him ahead, he turned and again getting astern, emptied his magazine at the German, who began to descend. Then the Englishman stopped his engine and began a down glide while reloading. Unfortunately the magazine jammed, but he managed to insert four cartridges and to fire them at his opponent who disappeared into a bank of clouds. The Englishman followed but never saw him again."

Although his enemy escaped in convenient cloud banks, this report indicates that the English pilot "on a fast scouting monoplane and carrying two rifles" was undoubtedly employed for the purpose of destroying hostile aircraft in flight. Here also the beginning of aerial combat tactics is revealed in the statements that "The English pilot obtained a position behind the enemy", and "he turned and again getting astern * * *." Thus aerial combat born of the twin requirements (1) maintenance of aerial observation of the enemy, and (2) denial of hostile observation of friendly forces, came to be accepted by military authorities as not only possible, but extremely desirable.

Due to the fact that the English began developing work upon fighter types earlier than the other nations, they were better prepared for aerial combat in the early days of the war than were the other powers. Among the early fighters employed by the British were the Maurice-Farman pusher, the Morane bi-place, the BE-2-C, the Martinsyde scout, the RE-5, the Bristol scout, the DeHaviland 2, the Vickers Gunbus (FB-5) and the FE-2 type.

It was found early in the war that the tractor type airplane did not permit of fire to the front due to the position of the propeller. For this reason efforts were directed toward developing the pusher type with the gunner mounted in the nose and equipped with a flexible gun. The FB-5 was an outstanding example of this type airplane and it was extremely successful in aerial combat in 1915.

From 1912--1914 French development had been directed toward producing high speed airplanes, thus a number of monoplane types were produced and were available at the beginning of the World War. Generally, however, these French monoplanes had undesirable flying characteristics and were not sufficiently strong to withstand the required maneuvers.

In Germany the authorities had restricted themselves almost wholly to the development of airplanes suitable for reconnaissance only. When the necessity for air combat was realized in the early fall of 1914, intense efforts were directed toward producing suitable types. In 1915 the Albatross, Aviatik, and the Fokker monoplane were produced. The performance of these airplanes was comparable to that of the French and British, but they were not produced in sufficient numbers to overcome the initial advantage of the English.

The production of specialized fighter airplanes led to a new problem; that of organizing and employing them correctly. Since these fighters were to support friendly observation and deny hostile observation, it was at first assumed that a number of fighters should be included in each observation unit as large as a squadron. It was assumed that the organization of composite tactical units would lead to close cooperation between personnel and would insure the presence of fighters in areas where reconnaissance was to be conducted. However, this composite organization was found to have a very serious weakness, after a few months' trial. This weakness resulted from the fact that the fighters, dispersed in small numbers among numerous units, were never sufficiently concentrated to achieve the effect of mass action. It was also found that the few fighters assigned to an observation squadron were unable to provide close support when opposed by hostile fighting craft. The British were the first to react to this deficiency, and during the fall of 1915 and winter of 1915--16, the Royal Flying Corps organized and equipped a number of fighter squadrons.

On the German side of the lines single-seater fighters were assigned to armies and groups of armies, in small numbers, for the purpose of defending both the observation airplanes assigned to those armies and the ground troops from the attacks of hostile aircraft.

Naturally, it was impossible to obtain an effective concentration of German pursuit at any given point under this system; in fact, the pursuit assigned to German armies was practically valueless. During the spring of 1916, Boelcke conceived the idea of organizing independent pursuit units for action wherever required in order to gain control of the air. The first squadron was organized and employed at Verdun. The Battle of the Somme, June 30--November 30, 1916, resulted in a complete change in combat tactics and organization in both the German and British Air Forces. From July 1 to September 15, the Royal Flying Corps so dominated the air that German observation was unable to operate effectively while British observation was able to carry out practically every mission assigned, with little fear of hostile aircraft. One report submitted by General Trenchard stated that for an entire week only fourteen hostile machines were observed crossing the line of trenches in the Fourth Army Area, while 2000 to 3000 British machines had crossed the same lines during that period. General Von Hoeppner states, with regard to this situation, that "One of the chief mistakes in the early weeks of the Battle of the Somme was the failure to recognize the importance of the single-seater pursuit planes. The Second Army (German) had few single-seaters and made poor use of what they had." In another place, General Von Hoeppner says, "Our pursuit and combat squadrons * * * were not suitable for this sort of mission and after having met with heavy losses they were obliged to give it up * * * *. All this was due, doubtless, to our numerical inferiority and to errors in employment which cannot be denied."

The situation on the Somme became so desperate that on September 15, Boelcke was transferred from Verdun to the Somme. On the morning of the 16th he conducted his first patrol with five airplanes and succeeded in shooting down five British planes with no loss to his own unit. During the next two months, Boelcke, personally, accounted for 20 British airplanes while his squadron was credited with a total of approximately 80 victories. The British had been operating with small units which broke up upon the first contract with the enemy. Boelcke, on the other hand, used larger units, which maintained some degree of cohesion throughout a fight. He was the first to teach teamwork in mass action. Although Boelcke was killed in an aerial collision in October, 1916, his teachings, of the value of concerted action by large numbers and of close teamwork by the individuals of small formations, were perpetuated by his former pilots and combat students. Among these former students was Richtofen, who became famous during 1917 and the early part of 1918 for his employment of large numbers of pursuit planes in concerted action. Richtofen's circus was transferred frequently wherever intense aerial activities developed and was never defeated as a unit. On the other hand, it inflicted serious losses on Allied aviation in every combat.

Summarizing methods of employment for pursuit during the World War, we have, in the beginning, the individual pilot acting largely upon his own initiative with regard to the area of his operations. Later, two-man teams developed where the lower man acted as "bait" for a more skilful team-mate flying above him.

During the Battle of the Somme, offensive patrols were conducted by designating definite patrol lines to be flown by small formations of pursuit. The Close Support method was also used during this battle. The Close Support method for employing pursuit required pursuit to fly in close proximity to the supported force. This deprived pursuit of initiative and aggressiveness.

In 1917 the barrage patrol was developed and used extensively. This form of employment was designed to deny certain areas to hostile aircraft. It consisted of the organization of a large pursuit force which conducted regular patrols through a great range of altitude around and over designated areas. The barrage patrol resulted in a tremendous expenditure of pursuit effort and did not accomplish satisfactory results. The exhaustion of pursuit from barrage patrols led to an attempt to conserve pursuit effort by employing fighting airplanes upon the alert. Under the alert method of employment, a few pursuit planes were sent into the air while the majority were retained upon the ground, the plan being that the planes on the ground would join those in the air after combat developed. Since pursuit combat is a matter of a very few minutes, it was found that the planes on the ground were usually unable to join those in the air before the combat was terminated.

Still another method of employing pursuit was developed for special situations. In the defense of London and of Paris, pursuit was kept on the ground until alerted by reports from distant observation outposts. It then took the air for the purpose of intercepting and attacking hostile aircraft approaching the defended area. This alert pursuit, once in the air, was unable to receive any further information of the enemy until the British employed radio receiving sets in pursuit airplanes in the spring of 1918. The majority of interceptions attempted by alert pursuit were unsuccessful, due to this lack of further information of the enemy.

Thus, at the close of the World War, there still existed a great deal of doubt and uncertainty with regard to sound methods of employment of pursuit. A few principles, however, had been developed and were generally recognized as such. Among these principles were:

(1) The value of surprise.

(2) The desirability of teamwork in aerial combat.

(3) The necessity for mass in order to obtain decisive results.

(4) The necessity for developing the most improved equipment for pursuit use.

(5) The necessity for employing highly specialized pilots in pursuit work.

(6) The necessity for providing interceptor pursuit after leaving the ground, with information of the enemy.

Accepting these principles as being sound, we are in position then to develop technique and tactics for the employment of modern pursuit.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 2

THE PURSUIT AIRPLANE

The relationship between equipment and tactics in pursuit work is very close. While almost any type airplane may be employed for other missions, only a highly specialized type can accomplish the pursuit mission with any degree of effectiveness. This requirement for a high degree of specialization is not generally appreciated even among air men. It is usually assumed that a pursuit airplane is effective for any combat mission. However, the field of pursuit employment embraces such a wide range of altitude and so many varying combat conditions that it is impossible for any one type plane and power plant to perform satisfactorily under all probable conditions.

Pursuit has the mission of forcing combat, in the air, upon all types of hostile aircraft. Thus it may engage hostile pursuit, bombardment, attack or observation aviation. Opposed to hostile pursuit, the maximum of maneuverability may be required. Opposed to bombardment, maneuverability is not important, but speed, climb and the ability to fire accurately at long ranges are of great importance. Bombardment may be expected to fly at medium to high altitudes, so that climb and ceiling become important characteristics of pursuit designed to combat hostile bombardment. Attack aviation may be expected to present the same tactical problem as bombardment except that attack will operate at very low altitudes, thus eliminating the requirements for rapid climb and high ceilings. Corps observation will usually operate at medium to low altitudes and will employ maneuverable airplanes of medium speed. Here the requirement for high speed and rapid climb for pursuit may be eliminated. However, Army and G.H.Q. Observation may operate at extremely high altitudes, as will most photographic airplanes, and opposing pursuit must have a fast rate of climb and high ceiling in order to deny freedom of action to these types.

During the World War, it was found, from experience, that certain types of pursuit planes had superior performance at definite altitudes. In the Royal Flying Corps, the Camel possessed the greatest degree of maneuverability at low altitudes, while the SE-5 was most maneuverable at high altitude. The British took advantage of these differing characteristics by arranging masses of airplanes with the Camels at low and intermediate altitude, while the SE-5s flew in support at high altitude. The Spad was able to withstand fast pull-out after a long dive; so pilots cruised the Spad at high altitude and invariably attacked from a fast dive. The Fokker D VII was able to stand on its tail for an appreciable time. German pilots took advantage of this characteristic by attacking from below the enemy.

After the end of the World War, the supercharger for both radial and Vee type engines was developed. Until about 1931, it was generally believed that the supercharger rendered a single type of pursuit

P-3
36-270
4-13-36
dw

airplane effective for combat at all altitudes. With the development of high-speed, monoplane bombers, however, it became apparent that a single type of pursuit airplane could not accomplish both the mission of engaging bombardment at high altitudes and a maneuverable type of observation or pursuit at low or intermediate altitude.

An attempt to provide a dual-purpose airplane, capable of performing both of these missions resulted in the production of the P-26 type. The P-26 is a low wing monoplane, super-charged, and has a minimum load factor of 12-1. Flown as an experimental type in 1931, it developed higher speed than any other military airplane in the world. Its climb and service ceiling were satisfactory. A quantity contract was negotiated for a large number of P-26's but the Martin type of bomber was developed before the first P-26's were constructed. This bomber, with a very low load-factor, developed speed approximating that of the P-26, thereby rendering the P-26 obsolescent. About 1933, the British produced two bi-planes, the Hawker and the Fairey, which had considerably greater speed than the P-26 and which were far more maneuverable. Other foreign countries followed suit, so that by the time the P-26 was produced in service quantities, it was exceeded in its performance by numerous foreign pursuit airplanes and was not comparable to the newer types of bombardment and attack airplanes.

Most textbooks include a table of characteristics for pursuit airplanes, arranged in the order of their relative importance. Such tables mean absolutely nothing unless the mission, for which the pursuit plane is designed, is stated. It must be realized today that no one type of airplane can conceivably accomplish all the missions pertaining to pursuit aviation. Generally speaking, these missions fall within two fields, interception and close combat. For Air Force missions, that is, for missions where the Air Force is acting independently of surface forces, interceptions will constitute the great majority of pursuit missions. We hear a great deal of discussion of a first phase in future warfare. It is assumed that during the first phase long-range aerial operations, directed against hostile airdromes and industrial centers, will be engaged in by all the combatant powers concerned in the war. Since these operations will be conducted at such ranges as to make it impossible for pursuit to take part, the only role open to pursuit will be to deny the penetration of hostile aircraft over friendly defended areas. Visualizing conditions which will probably exist in such a situation, we may assume that hostile bombardment will constitute the principal threat to those defended areas. However, it will be desirable to deny penetration of those areas to hostile observation also, since the enemy will depend upon his observation for the location of targets for his bombardment.

Both hostile bombardment and long-range observation will undoubtedly fly high and will employ airplanes with considerable speed at altitude. Therefore, defending pursuit must be equipped with an airplane capable of climbing at the greatest possible rate and also capable of attaining considerable speed in level flight at altitude. Since neither of the types of enemy aircraft named may be expected to engage in violent maneuvers, but rather will depend upon speed or numbers for defense, the interceptor pursuit type need not possess a high degree of maneuverability. For the same reason the strength factor of the interceptor type may be lowered far below that required for fighter type pursuit planes. The English realized that an interceptor would not be required to engage in violent acrobatics several years ago, and as a result, the English have produced bi-planes with a load-factor of 8 to 1 which out-perform our present monoplane interceptors. With regard to the question of lowering the load-factor, an argument is sometimes advanced that an airplane incapable of being put through the most violent acrobatics will operate to lower the morale of the pilots. Such an argument is absurd, because we have today numerous types of bombardment, attack, observation, and transport planes which cannot withstand violent acrobatics. It should be clearly understood by everyone concerned, that the interceptor pursuit type is a very highly specialized type of airplane, designed for a particular purpose, just as the latest bombardment plane is designed for a particular purpose; that the interceptor type has distinct limitations which must be respected.

The armament for the interceptor should also be highly specialized. It should be equipped with long-range weapons, capable of attaining considerable accuracy beyond the ranges of the defensive weapons carried by bombardment. For this purpose, a cannon of not less than 20-mm caliber should be installed as the principal weapon. Supplementing this cannon, there may be one or more machine guns of .30 or .50 caliber for employment at close ranges in special situations. As additional armament, the interceptor should carry, normally, a minimum of 10 time-fuzed bombs of not more than 15 pounds weight each. Accurate sights should be developed and installed for the cannon and machine guns at all ranges and for dropping the time-fuzed bombs with the desired degree of accuracy.

It is apparent that this interceptor type airplane will not be suitable for engaging in combat with a highly maneuverable type hostile plane. For close combat between rival pursuit forces, or between pursuit and maneuverable observation types, an airplane with a high strength factor and the maximum degree of maneuverability is required. Also, the requirements for armament are different from that of the interceptor type. Large caliber guns, accurate at long ranges are not required here. The majority of the combats in this field will be of the maneuvering or dog-fight type. The objective of the pursuit pilot will be to kill the opposing pilot, and for this purpose a small caliber machine gun, with a high rate of fire, is the most desirable weapon. This field of pursuit employment relates almost altogether to the support of ground army operations. We have prepared elaborate plans for the mobilization and employment of four field armies. We actually have a sufficient number of National Guard and Reserve observation squadrons for assignment to these armies and to the corps composing the armies, but we do not have a single pursuit unit or pursuit airplane designed for the purpose of supporting army and corps observation or for denying hostile observation of the same types. The trend of development in pursuit equipment is more and more toward the highly specialized interceptor type, so that in the future it may be expected that the interceptor and the close combat types will be even less interchangeable than they are today.

In view of the high degree of specialization attained in airplanes of all other classes of aviation, the time has arrived when the all-purpose pursuit plane must be abandoned in favor of, at least, two types of highly specialized pursuit airplanes. To continue further the attempt to perform all pursuit missions with the single type airplane will inevitably result in the complete failure of pursuit to perform any of its assigned missions in a satisfactory manner.

At this point it is appropriate to discuss the two-seater pursuit plane and the proposed multi-seater battle-plane. A number of efforts have been made to produce a two-seater pursuit plane which would be more effective than a single-seater. Supporting this project there have been advanced any number of arguments in favor of the two-seater. To mention a few, there is the argument that only the two-seater can break off combat; that only a two-seater can engage hostile formations from level flight; that the two-seater is more effective offensively, because it is not required to maneuver for defense; that the two-seater can be built with much greater range than the single-seater; that it can be used as a reserve for the single-seater; that it can provide special support for other classes of friendly aviation.

Without going into a lengthy discussion of all these arguments, it should suffice to point out that the two-seater is a compromise, -- an attempt to combine in one vehicle both offensive and defensive fire power. Experience has taught that any compromise between two or more conflicting characteristics results in the production of an article which is less effective in one or both fields of activity than is an article designed exclusively for the highest degree of effectiveness in one field only. The two-seater pursuit plane is no exception to this invariable rule.

With regard to the proposed multi-seater battle-plane, we are told by the advocates of this project that the battle-plane can be built with considerably greater fire power, and with superior performance, than a contemporary bombardment plane. We also hear plans for maintaining a number of these battle-planes in the air over a defended area for the purpose of preventing the penetration of hostile bombardment. We hear other plans for assembling these battle-planes in aerial fleets with a view to laying alongside the hostile bombardment fleet or battle-plane fleet, and engaging in fleet actions with heavy guns. It ~~has been~~ found impracticable, if not impossible, to construct a battle-plane with superior fire power and greatly superior performance over contemporary bombardment types. The design of such a plane would be such as to permit its ready use as a bomber. The removal of the heavy armament and the substitution of bombs for this armament and ammunition load, would produce a bomber with flying characteristics greatly superior to those of any other bomber. Assuming that the enemy was able to do the same thing,-- both sides would then have bombers which could not be forced into combat by hostile battle-planes. The proposal to maintain the fixed defense of battle-planes constantly in the air, over defended areas, is most impracticable. It was proven on many occasions during the World War that airplanes could not maintain a fixed defense and that any attempt to do so invariably resulted in exhaustion of the defensive forces with little or no damage to the enemy. Such an attempt would also violate the principle of economy for these battle-planes would necessarily be expensive and a large number would be required to maintain a considerable force in the air at all times. The employment of expensive defensive planes is inconsistent with one of the principles which should govern pursuit development, that is, the principle of cheapness. The pursuit plane should be cheap, both in regard to monetary cost and to time and labor required to construct it. The loss of two or three pursuit planes in exchange for one hostile bombardment plane should result in an economic advantage for the defense.

The idea of aerial fleet actions is interesting, although there does not seem to be any prospect for such actions in the near future. The construction and employment of a very expensive airplane for the purpose of engaging in battle with a hostile airplane, of the same general type, cannot be justified from either a military or an economic viewpoint. An aerial combat, considered independently, with no relation to the action of other air or surface forces, has no point.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
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Course: PURSUIT AVIATION

CONFERENCE NO. 3

THE ROLE OF DEFENSIVE PURSUIT

The designation, "Defensive Pursuit", as used in the title of this conference is a striking illustration of the inaptness of accepted military terminology when applied to air force operations. Since ancient days, any military force or effort which was not designed primarily for the invasion of hostile territory has been classed as "Defensive".

In accordance with this ancient definition, Interceptor Pursuit is a defensive force, although its tactical employment is wholly offensive. In fact, it would be extremely difficult to conceive of a force more offensive in its characteristics. With no necessity for providing for its security in the air or for holding out a reserve, it is planned to employ every individual in the Interceptor unit for the offensive function of <u>forcing</u> combat upon hostile aircraft.

It is true that the anticipated combat between Interceptors and hostile aircraft will begin over territory friendly to the Interceptors but it may often occur that this combat will terminate over hostile terrain. However, it is not necessary to argue about the name applied to this class of pursuit since the role of the Interceptor is so clearly defined as to readily distinguish it as a highly specialized class of aviation with distinctive equipment, tactics and technique.

Any study of this subject must necessarily consist of the consideration of the numerous factors which pertain to or determine the role of Interceptor Pursuit. Of these factors, the following will be considered in this conference:

(1) Function
(2) Physical location of units
(3) Organization
(4) Equipment
(5) Factors pertaining to the interception of hostile aircraft.

The correct statement of the function of Interceptor Pursuit is, "To intercept and attack designated hostile aircraft flying within its range of action". It is unnecessary to include "the disorganization and destruction of hostile formations" as they are tactical objectives whose attainment is contingent upon interception and attack.

This functional definition is often incorrectly stated as follows, "To defend a designated point or area from the attack of hostile aircraft". In this case, the action of the pursuit force is confined to a limited area and to the strictly defensive attitude of attacking only the hostile aircraft which may attempt to penetrate into the designated area. The computation of the numbers of aircraft required for the local defense of a large number of areas, such as might be anticipated in a defense of the United States, results in a total far beyond the possibility of attainment.

P-3
36-270
4-13-36
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The location of Interceptor Pursuit units depends upon the geographical location of the two hostile states.

Thus, in a war between states having a common boundary, we should expect to find Interceptor units located in a narrow belt paralleling the border and at sufficient distance from the border to accommodate the time and space factors required for timely interceptions. The distance between the border and pursuit airdromes depends upon the characteristics of hostile and friendly aircraft and the efficiency of the ground aircraft reporting service. In no case should pursuit airdromes be so advanced as to require the approach to the interception to be made from the rear of the hostile force.

The approach from the rear requires the interception to be made at a rate which represents the difference in speed between hostile and friendly airplanes--never a very large figure. On the other hand, the approach from the front of the hostile force permits an interception speed equal to the sum of the speeds of the two forces. While an exact head-on interception may never be attained in practice, the objective of the intercepting unit should be to make every approach at an angle less than 90° to the enemy's line of flight.

This principle pertaining to the angle of approach was not appreciated in the past and is not generally understood today. We still hear statements that it is necessary for pursuit to fly at altitudes thousands of feet above the enemy formation so that it can decrease the time required for closing to combat by diving down from the rear. A moment's reflection should convince anyone that superior altitude is not required if the approach is conducted from the front and the final closing to combat is effected by properly timed turns made in the vicinity of the hostile force.

Another error of the past was the belief that interceptions were facilitated by advancing pursuit airdromes as near the border or front lines as possible. The fallacy of this theory was clearly demonstrated in the 1931 Royal Air Force Maneuvers. The objective of these maneuvers was to test England's air defense installations, with particular attention to the ability of pursuit to make interceptions.

For this purpose, English pursuit units were located on airdromes beginning at the coast and extending back to the vicinity of London. The "enemy", represented by bombardment units of several types, was required to cross the coastline on each attempt at a penetration. The fastest pursuit squadron, equipped with the high speed, 215 miles per hour, Hawker "Fury" was based within sight of the Channel while slower units were on airdromes deeper in the interior. During maneuvers lasting two weeks, the squadron of Furies was unable to make a single interception before the "enemy" arrived over his target. One hostile Hawker "Hart" squadron, high speed 176 miles per hour, was intercepted before reaching its target on every attempt by units equipped with pursuit planes having a margin of speed less than ten miles per hour. All pursuit units operated under identical conditions except the one factor--distance of airdrome from the border or front.

This experience not only proved the fallacy of the theory that Interceptor pursuit units should be pushed as far forward as possible but provided the R.A.F. with valuable data for determining the depth of space required for timely interceptions. This space factor will be discussed in detail later.

In a war such as might require the defense of the United States against an enemy making his major effort by the attack of powerful air forces, we may expect those forces to be concentrated in a definite area. This area may be as large as some of the European states but it will certainly have definite limits which can be established. The difficulties of maintaining communications, of command and supply will force considerable concentration of the hostile air force. The necessity for concentrating hostile effort upon a designated area of limited extent in order to obtain decisive results quickly will insure against the dispersion of hostile units over such distances as thousands of miles along our borders and seacoasts. There will be no point in having some hostile units in range of our Pacific or Gulf Coasts if the objective of the enemy is to paralyze the industrial area of the northeastern states.

This concentration of hostile forces will result in "fixing" the enemy so that his air attacks must come from one general direction. The proper location of our Interceptor pursuit units in such a situation will be in a narrow zone as far forward (toward the enemy's concentration area) as is consistent with the requirements for timely interceptions. This airdrome zone will be established so as to intersect the nearest line of approach from the hostile concentration area to our most vital area within his range. It will extend to each side of the nearest line of approach as far as the number of our Interceptor units will provide effective concentrations or geographical features will permit.

The location of Interceptor units in this manner will permit pursuit to concentrate in effective numbers against hostile formations and will enable all available interceptor units to expend their maximum combat effort. The employment of Interceptors for the local defense of numerous areas will result in such dispersion of forces that an effective force will not be available in any single area. On any given day, the majority of the Interceptor units defending local areas will have no combats while a few units will be required to engage greatly superior hostile forces.

The employment of Interceptors for local defense may be justified under certain special conditions. For instance, a state having but one vital area should certainly concentrate all of its Interceptor pursuit for the defense of that area. Thus, during the World War, German air attacks upon the British Isles were concentrated upon London and its suburbs.

In some situations it may be expected that the major hostile air effort will be directed against our airdrome areas, initially at least. The location of Interceptor units so as to facilitate the interception of hostile aircraft engaged upon missions against our airdromes will afford our Interceptors the opportunity for expending maximum combat effort. In any case the Air Force is of such vital importance and is so vulnerable when immobile upon the ground, that the minimum requirements for its security will necessitate the assignment of an Interceptor force of considerable size to that mission alone.

The organization of our present G.H.Q. Air Force is such that Interceptor pursuit is provided in numbers barely sufficient for satisfying normal requirements for the security of Air Force airdrome areas. No pursuit airplanes or units are provided for the general defense against hostile air attacks or for army cooperation. This deficiency in pursuit will have no ill effect if our counter-offensive force is successful in quickly destroying the hostile striking force and if there is no necessity for army operations. However, our counter-offensive may not be wholly successful or the army may be required to take the field. In either case a period of at least eighteen months will be required to correct the initial deficiency in Pursuit Interceptor and Fighter type airplanes.

At present, three pursuit groups composed of three squadrons each are authorized. An additional squadron for each group is assigned to school duty. For an emergency, we have available nine squadrons of pursuit.

Two pursuit groups are now assigned to Composite Wings, one each of bombardment and attack. Experience indicates that the assignment of pursuit to composite organizations provides no tactical advantage but results in such dispersion of pursuit forces that effective concentrations at any one point are impossible. However, the composite organization in peacetime does afford pursuit opportunities for training with other classes of aviation.

In order to obtain the maximum degree of effectiveness, it is believed that Pursuit should be organized in Wings consisting of three groups and groups of four squadrons.

The three group wing provides sufficient strength for long continued operations and, on occasion permits pursuit to engage in sustained action with large hostile concentrations by successive group attacks. The effect of engaging the enemy with fresh groups at intervals of fifteen to twenty minutes cannot fail to be cumulative. The enemy will be less able to resist each new attack.

For routine "Alert" duty, the Wing of three groups permits a rotation of groups on the alert so that repairs to equipment can be made while flying personnel are resting.

The Group of four squadrons provides sufficient mass strength for the majority of operations. Fewer squadrons would result in ineffective combats and more than four squadrons would result in providing an unwieldly group which could not find space for the engagement of all of its units. The four-squadron group also facilitates the simultaneous attack on hostile formations from four directions.

Experience indicates that the squadron of eighteen airplanes in three flights is the most effective squadron organization.

The subject of equipment was discussed in the conference on the Pursuit Airplane. However, for the sake of emphasis, the principal points with regard to the equipment provided for Interceptor units will be repeated here.

The Interceptor airplane must be able to climb at the maximum rate. It should possess high speed at altitude. It need not be highly maneuverable and does not require a factor of safety which will enable it to withstand violent acrobatics at high speed. Its armament should include a light gun of 20 to 25 mm. capable of delivering accurate fire at long ranges. Pending the development of such a gun, .50 caliber machine guns should be installed. The Interceptor should carry and be able to drop accurately a minimum of ten 15-lb. time-fuzed bombs. A load of twenty 10-lb. bombs would be preferable. The accessories to flight such as radio and oxygen should be provided. Above all, the Interceptor should be a small airplane, presenting the minimum target area to hostile gunners, and should be economical in construction, both with regard to cost in money and in time required for production.

The principal factors pertaining to the interception of hostile aircraft are:

(1) Time
(2) Space
(3) Information of the enemy
(4) Visibility.

The time factor affects the problem of interception at the following points:

(1) Time required for the collection and transmission of information of the enemy and for issuing orders.

(2) Time required for defending forces to leave the ground after receiving the order.

(3) Time required to fly from defending airdromes to the point of interception.

The time values for the first and second operations may be reduced to minimum figures by intensive training of personnel and proper organization. During the Fort Knox Maneuvers, 1933, the average time required for the receipt of information of the enemy was more than two minutes while the time required for the take-off varied from five to fifteen minutes. For the Miami Maneuvers, 1935, messages pertaining to hostile aircraft were assumed but the average time required for the take-off was about four and one-half minutes. A comparison of these time values with those attained by units of the Royal Air Force shows how much can be accomplished by training and proper organization. An M.I.D. report on British Air Maneuvers, 1931, states, "Raid warnings are received and plotted in the operations headquarters within half a minute. The interceptor squadron would receive its instructions within three minutes of a raid's crossing the coast and would be in the air within five minutes". A careful study must be made of all the operations required for an interception with a view to reducing to the minimum the time required for each phase.

The time required to fly from Interceptor airdromes to the point of interception will vary with each mission. It is determined by such factors as the route, speed and altitude of the enemy, the location of pursuit airdromes with reference to the route of the enemy, and the speed and rate of climb of Interceptor airplanes. The reduction of this time value to the minimum consistent for effective operations results in the conservation of pursuit effort.

The space factor is the principal consideration in determining the location of Interceptor airdromes. The space factor is determined, principally, by the extent and effectiveness of the ground aircraft reporting service or alert net. Sufficient space must be provided between the Interceptor airdromes and the farthest points where information of the enemy will originate to accommodate all the time values necessary to making a timely interception of hostile aircraft.

The calculation of the space required for an interception is comparatively simple when all the time values, the performance of hostile and friendly aircraft, and the meaning of timely interception are known.

For illustration, assume that Interceptor pursuit desires to make a head-on interception of a hostile force flying 210 miles per hour, at 15,000 feet on a course which will bring it over the vicinity of the pursuit airdrome. The Interceptor can climb to 15,000 feet at an average rate of 2,500 feet per minute with a forward speed of 120 miles per hour. In order to comply with the tactical requirements for a timely interception, pursuit must make contact with the enemy 6 minutes before he arrives over the pursuit airdrome. Assuming that the total time required for receiving information of the enemy, issuing the order to take off and for taking off is 6 minutes, we set up the following equation in order to determine the time required for pursuit to arrive at 15,000 feet: $6 \text{ plus } \frac{15,000}{2,500} = 12$ minutes. Of this 12 minutes, 6 minutes apply to the space factor, for during 6 minutes pursuit moves forward at the rate of 120 miles per hour. During the entire period of 12 minutes, however, the hostile force is approaching at the rate of 210 miles per hour. Therefore, in order to arrive at the value of the entire space factor, the following equation is set up: $\left(12 \times \frac{210}{60}\right) + \left(\frac{15,000}{2,500} \times \frac{120}{60}\right) = 54$ miles. Pursuit can make interception under the conditions named if information of the enemy originates 54 miles from the pursuit airdrome. However, the interception will occur but 12 miles from the pursuit airdrome which does not satisfy the requirement of 6 minutes for a timely interception. Six minutes at the enemy's speed is equivalent to 21 miles of distance. Assuming that the Interceptor's high speed in level flight at 15,000 feet is 270 miles per hour, it is apparent that pursuit must fly 2 minutes at this speed in order to make the interception 21 miles out instead of 12 miles; an increase of 9 miles in the space factor. During these 2 minutes the enemy will cover 7 miles. The total space requirement then is $(54 + 9 + 7) = 70$ miles.

An analysis of the assumptions made for the purpose of illustrating the method for calculating the space factor leads to the conclusion that several values may be altered by the training of personnel, and the production of improved equipment. Five minutes instead of six should suffice for the collection of information and the take-off of an Interceptor unit. The high speed of the Interceptor at 15,000 feet should be 300 miles per hour and can be obtained easily if a specialized Interceptor type rather than an all-purpose type of pursuit airplane is provided. The average rate of climb to 15,000 feet can be increased to 3,000 feet or more per minute by the same means. The Interceptor airdromes will usually be located well in advance of possible targets for hostile bombardment so that there will be no necessity for making interception 21 miles in advance of those airdromes.

In conclusion of this discussion of the space factor, it is believed that well-trained Interceptor units equipped with properly designed airplanes and operating on information furnished by an efficient aircraft reporting service can make interceptions consistently when located fifty miles from the outermost observation posts. Poorly trained units equipped with all-purpose airplanes may require one hundred miles for any interception and will be unable to make interceptions consistently.

There are two agencies which are capable of collecting and transmitting information of the enemy, aerial observation and the ground Aircraft Reporting Service.

Aerial observation has the advantages that it may extend out farther and that it will usually provide more accurate details regarding the type, altitude, and course of the enemy. However, if aerial observation alone is relied upon for information of the enemy, it is obvious that a prohibitive number of observation planes will have to be employed in order to thoroughly patrol all areas over which the enemy may approach. Aerial observation is of little value for such work at night and the transmission of its reports over considerable distances is uncertain and unreliable.

The ground aircraft reporting service, sometimes called the Antiaircraft Warning Service, the Alert Net, the Alarm Net, and Aircraft Warning Service, is able to operate both night and day and in any weather when flight is possible. Information from its observation posts is transmitted by wire and is not subject to interference by the enemy.

It is known that England, Germany, France and Italy have developed effective aircraft reporting services covering all areas where possible targets for hostile air attack are located. Of all these systems, the details of the English net are best known. However, the principal features of all the systems are similar. These features are:

(1) The immediate location and report of hostile aircraft entering the net.
(2) Periodic reports of the enemy by successive posts at frequent intervals.
(3) The use of pursuit and ground guns to deny freedom of action to the enemy as well as for his destruction.
(4) The coordination of all defense installations, both active and passive, under one authority.

The aircraft reporting service is the basis of successful air defense. Its value is stressed in a volume entitled, "Air Defense", by General E. B. Ashmore. It is necessary even if nothing but purely passive defense measures are contemplated and it is absolutely essential for the successful execution of offensive measures. Since it is the basic requirement for air defense, the organization and equipment of this service should receive priority over all other defense measures, even the production of Interceptor type airplanes.

The details of the organization of the aircraft reporting service and the technique involved in its operation will be discussed in the next conference.

Visibility effects the problem of making an Interception less today than during the World War. Due to the fact that the progress of the enemy force will be reported at frequent intervals to the Interceptors by radio, it is believed that pursuit can make interception under any condition of visibility when the enemy will attempt to operate in force. Single airplanes may use clouds to shield their approach to a target and to escape attack but large formations will have great difficulty in locating and attacking a target except by flying in the clear for a considerable period of time.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: PURSUIT AVIATION

CONFERENCE NO. 4

THE AIRCRAFT WARNING SERVICE AND ALERT NET

The use of the word "Warning" in the name of this service does not convey the proper meaning. While the service may warn, its basic requirement is to report accurate details with regard to hostile aircraft flying over the net. The use of the word "Reporting" in the title would convey a far more adequate idea of the requirements of this service than does "Warning".

The German Alert Net is somewhat different in organization to that of any other nation. Exposed to possible air attack from every direction, German air defense is planned on a series of concentric circles with defense areas prescribed by radial lines radiating out from the center of the country to the borders.

Observation--Listening posts are located at distances of 15 to 20 kilometers apart over the whole country. From 5 to 10 posts are connected by direct telephone lines to an Information Center while two or three Information Centers are connected to a central Intelligence Center. This organization completes the net for a single defense area or sector, but all defense areas are connected directly with General Defense Headquarters. General Headquarters directs the application of both active and passive defense measures in threatened areas.

The English net covers the industrial regions and centers of population of England and Scotland only. Its general shape is irregular but more rectangular than round. Its organization is practically the same as the German, except that more Observation-Listening posts are connected to each Information Center, about 15 to each Center. The Intelligence Centers are eliminated by connecting Information Centers directly to Defense Headquarters. There are no clearly defined defense areas since the objective seems to be the interception and destruction of hostile air forces penetrating toward the interior. As in Germany, air defense headquarters is charged with the conduct of all defensive operations, both active and passive. It controls all the agencies of defense, including Interceptor pursuit, ground guns, the Aircraft Reporting Service, searchlights, balloon nets, artificial smoke devices, the darkening of areas, the cessation of industrial activity in threatened areas, and the operations of fire, sanitary, and chemical squads.

Personnel for the operation of the Aircraft Reporting Service belong to the Observers Corps, a reserve military organization. The policy of assigning members of this corps to duties in the vicinity of their homes is strictly adhered to in so far as is possible.

A number of units of the Observers Corps are called to active duty annually for the operation of the net and other defensive measures

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during the period devoted to Royal Air Force Maneuvers.

The Italian Aircraft Reporting Service is organized to cover all the provinces of Italy except the marshy maritime provinces which contain no profitable targets for hostile air attack. Italian defensive measures are so detailed as to include the sandbagging of monuments and the protection of valuable works of art.

The latest reports on the French air defense system indicate that six areas only have been designated for defense and that the defense of each area will be an independent operation. This plan must result in the division and dispersion of available equipment and may lead to ineffective defense in one or all areas. Certainly an offensive effort can be prepared which will be able to overwhelm the defense in a single area. No recent reports on French defense measures are available and it is probable that this plan for the local defense of six independent areas has been abandoned in favor of a centralized system which will be able to concentrate defensive effort to resist hostile air invasion rather than to attempt to defend designated points from hostile air attack.

Explain the diagrammatic representation of an Aircraft Reporting Service for the Montgomery Area.

Explain the square and the round interception maps, pointing out the differences in technique involved in the operation of the two methods.

Explain the organization and technique for making night interceptions.

THE AIR CORPS TACTICAL SCHOOL
Maxwell Field, Alabama
1935--1936

Course: OBSERVATION AVIATION

LECTURE
ON
AIRSHIP OPERATIONS

It is not the purpose of this assignment to teach you the entire subject of Airship Operations or Aerostatics; it is rather the purpose to give you a picture of what an airship commander is faced with every time his ship flies. Also, what he is faced with even when his ship is not in the air. For an airship once off its cradle and containing within its hull the forces of lift, must be carefully tended, even as a surface vessel. A gas leak--and there is trouble. This neglected, and often there is the loss of the vessel or airship, as the case may be.

You were given the simple equation of flotation or lift, and that is all there is to the business. But that is more than may seem when presented so simply. When this equation amounts to equilibrium, all is well. However, the fault of lift is that so many variables enter into this equation that none may be neglected the least bit, or the resulting troubles form an avalanch and like a huge snowball rolling down hill, gets rapidly larger by the second until it can no longer hold together and consequently disintegrates from the forces acting at cross purposes within.

No airship pilot can possibly be a success for long, who does not see those forces in the very beginning, and do something about them; either stop their action entirely or coordinate them in a fashion to operate the airship. There are a great number of these forces acting upon an airship and they are continually changing. In May, 1914, old Count Zeppelin is quoted as having said: "The forces of Nature cannot be eliminated; but they may be balanced one against the other". Like Orville and Wilbur Wright, Zeppelin appreciated thoroughly the scope of his problem and to that, his success may undoubtedly be ascribed. Real success he did achieve in his field. It is only those who have neglected Zeppelin's findings or who have tried to change their basic fundamentals, who have come to grief.

Lift in an airship or an airplane is a simple thing when we think of it as a plane being pushed along and up; or a bag with gas floating it, and also being pushed along. But it is not so simple when we have to explain that pursuit ships do not carry mail so well as planes constructed otherwide would do; that we cannot fly in planes icing up without some limit to the icing, or that we cannot lift just any load to any altitude with just any type plane. No, we have learned through years of grief, the loss of many planes and as many of our friends, the pilots, that we must "balance the forces of Nature". Nothing in aerostatics is

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so disgustingly simple as the start of a free balloon flight under ideal conditions; but let the least of Nature's forces start anything, and all is changed with startling rapidity. Human life amounts to nothing more than does that of a tiny ant clinging to a leaf in a whirlwind. The planning of a mission requiring a flight by either a plane or an airship should be done only by one who appreciates Nature's forces when and where they must be met. It is my hope to give you a small picture, at least, of these forces as they affect the airship and particularly as regards the problem of lift.

We have stated that lift = Wa - Wg, and that it is affected by:

Barometric pressure,
Temperature,
Humidity,
Purity (Sp. Gr.) of lifting gas.

Let us now consider a practical problem in balancing these forces to our purpose.

We will consider a ship of 7,058,823 cu. ft. volume. Ships are not ordinarily operated completely full of gas, but usually have a certain percentage of volume available for expansion, so that some altitude may be attained without valving the gas due to corresponding expansion as the ascent is made. (Law of gases.)

We are operating our ship at 85% fullness. This allows for 15% expansion, which may be caused by a change in temperature, barometer, or a combination of both, while still on the ground. It also permits ascent to the point in altitude where the density has decreased to 85%, or, roughly, 5000'+. At this point the ship will be 100% full of gas and any additional rise will necessitate valving gas. The ship at 85% full at sea level will contain 6,000,000 cu. ft. of gas.

We must know the condition of the variables affecting our lift. They are: Barometer 30"; Temperature 32° F; Purity of gas .98; Humidity zero or dry air; Time 4:00 AM (or there is no sun and we assume no superheat).

From our lift formula, or the curve constructed as a handy substitute in actual operations, we find: under above atmospheric conditions--

Lift per 1000 cu. ft. of helium = 68.4 lbs.
68.4 x .85 V = 410,400 lbs. lift under conditions as given.

The fixed weight of our ship, including crew, is 210,000 lbs. and the useful lift that may be used for fuel, bombs, munitions, etc., is 410,400 - 210,000 = 200,400 lbs. This is all we can load on under the conditions given. However, if conditions are such that we can wait until there is some superheat, we may expect considerable increase in this useful lift. We will suppose that it is 10:00 AM and that the ship was taken out of the shed during the night's calm and is now riding on the mast. The temperature is 52°F (rise), Barometer - 30" (no change), Purity - .98 (no change), Humidity - .00 (no change). Due to the change in Air Temperature, the Air Density will have decreased; but the law of gases is such that the lifting gas will have increased a corresponding amount and if no other change in condition existed, the lift would be unchanged, with the ship still in equilibrium. However, due to the effect of superheat, the temperature of the lift gas has increased over the air temperature by +30°F, with the consequence that the volume of lift gas has increased by 6%. The result is a 6% increase in the total lift or 24,624 lbs.

It is, therefore, evident that the time of take-off with an airship will determine what load can be carried. In this case it was about 12% increase in useful load. The same forces will affect the airship's landing, and often must be considered, if lift gas can not be thrown away by valving. Our policy is not to valve helium. However, if hydrogen can be used, it is cheaper and simplifies operation. In the above case we would simply have added 6% more hydrogen, taken off earlier, and valved it to reach the 5000' altitude. If the occasion warranted, we could and would handle helium the same way.

In the problem, we have considered our variables with only the slight change in superheat. Any other change would cause corresponding changes in lift. For illustration, we will consider one more. The air, instead of being dry, has become saturated and there is 100% humidity. The result is a loss in weight of air displaced and consequently a loss in lift. In this case it amounts to one-half of one per cent., or, roughly, 2000 lbs.

Since the air is never absolutely dry, there is always some effect from humidity. A good operating policy is to carry enough disposable load (usually water ballast) to offset the probable effects of this and other minor variables.

The airship's pilot is faced with considerably more of a problem in the organization of his crew than is the case of other aircraft pilots. He is more an executive; and on large ships the scope of the job is very similar to that of the captain of a large surface vessel. The training to fit one for such a job should be the equivalent of that required of a surface vessel captain. He must not only be a pilot; he must be able to coordinate and organize the duties of as many as seventy or eighty pilots, who likewise are highly trained and may be said to be specialized pilots. Such a commander is difficult to find in our country, due to lack of previous opportunity for the training. Only with continued airship operation can we expect to train them. The remarkable success of the Germans may be attributed to this training that has been theirs, through practically the only real airship operation of any consequence in the world.

On all airships it is necessary to conduct routine checks and maintenance duties both in the hangar and during flight. The commander must actually know that the checks are O. K. and on schedule. He divides the duties so that responsible department and section heads assure 100% functioning of all parts of an airship. The failure of any department will likely cause some degree of failure in the ship's performance. It may even cause a wreck. Considerable preparation and check is required before an airship can leave the ground. This must be appreciated and allowed for, or trouble and possibly failure is apt to occur, even in the take-off. Any large aircraft goes into trouble slowly but surely, and once in, comes out equally slow and is handled with correspondingly greater difficulty. "Prudence without timidity" is a virtue that has no equal for the airship commander, save, perhaps, the twin virtue of "boldness without rashness".

In the majority of cases, training rather than structure failure, has played the main part in our past catastrophes. This has been amply evidenced by many operations where ships have been partially torn up, and yet, have by the evident skill and training of their crews, been returned safely to their hangars. Some of these cases are discussed here, because,--though it may seem a defense for the airship,--it will also give you a fair idea of some problems in operation.

Early in her career, the naval airship "Shenandoah", while testing out mooring mast operation tactics, tore loose from the high mast at Lakehurst in a wind approximating 65 miles per hour. Her nose was completely wrecked and certain gas cells deflated, with consequent loss of lift. Her pilot quickly discharged water ballast enough to offset the loss of lift, and she floated rapidly down wind until her motors were started. Then, with some emergency repairs by the crew, she returned to her base under control and in flight some hours later.

The "Los Angeles", returning from a trip to Panama, was being hurried into the hangar ahead of an approaching snow squall. The maneuver was too late, and the squall catching her broadside, tore all the docking rail cables loose on the windward side. To save the ship, all lines were cast loose and the ship's commander discharged enough ballast to lift her into the air as a free balloon. There the motors were started and she flew out to sea and around the storm, returning when the storm had passed, eleven hours later.

The Army Semi-Rigid Airship returning from San Antonio, Texas, to Scott Field in 1928, encountered thunder squalls at Dallas, Texas, and was forced to bear eastward. Through the night conditions became so bad that the ship flew into low clouds with zero visibility a large part of the time. At sunrise she had crossed the Mississippi River and was over the State of Mississippi. Of 13 radio stations to call, only one functioned and that one had been operating with the ship since early the evening before, from Muscogee. The operator was unable to give any weather data, except right in Muscogee. This he reported as being terrible. He 'phoned Scott Field and the report was average, with the future forecasted worse. There was barely enough fuel to have gone to Langley Field, with no reserve in event of an emergency. There was too much wind opposing a return to San Antonio. The possibilities for going to Pensacola were not satisfactory.

A decision was arrived at, to proceed north downwind and attempt to make Scott Field; if shut out of there, to then proceed east, to Langley and possibly land somewhere en route if necessary, for fuel.

At Memphis, thunder squalls began forming. However, we then were in radio contact with Scott Field where the weather was still average and forecasted to remain so until dark. It was then noon and if we could get through it was about a six hours' flight to Scott. We had been out about 27 hours and decided to continue north.

While in a left turn between two squalls, we were sucked into a small squall. We dived, under full power to just over the tree tops and passed out under this squall, headed west. There, just in front of us was the most perfect line squall I have ever seen. It had all the trimmings of the specimen shown in pictures by meteorologists as examples. It had to be avoided and no matter how. We turned back into the little squall and plowed through to the southeast. The result was a terrific beating by the elements and our rigid nose structure collapsed. The girders had all broken loose from their anchor plate at the nose point, and were just flapping around. The bag was still O.K.

We slowed down to 40 miles per hour and headed back south and east, while with spare cables we made temporary and emergency repairs by lacing the girders back to the nose plate. By radio we asked Scott to telephone Murphreesboro, Tennessee, to be prepared to land and refuel us, as it appeared impracticable to continue to Scott under present conditions.

However, in the meantime, conditions had become much worse locally and we were surrounded by line squalls. With a crippled ship we could not fly faster than 50 miles per hour. There appeared only one direction where even a "pink sky" showed. That was south. We headed that way. When apparently we were about out of the squalls, we were suddenly sucked rapidly sideways into the last one. We headed directly away from it, but no luck. Fifty miles was not enough; we were sucked into it backwards, tail up, and the ship rose, through howling winds, hundreds of feet, still flying nose down about 30° at 50 miles per hour. Finally, down we went and were apparently going to plow into the earth because with full up flipper the ship would not respond. Finally, and just before hitting, the nose lifted and we missed. But back up we went again and repeated the first "up and down" seven times.

Finally we came out, on the west side of the main line squall with clear weather north to Scott Field. We found the loose girders had made dozens of holes in the gas bag. We fixed these and later arrived at Scott at 8:00 PM.

It sometimes happens that there is an emergency requiring immediate flight and without any time for preparation. For this reason, even on small blimps, a crew sufficient to fly the ship must always be on board, when going in or out the hangar.

One day at Aberdeen Proving Ground we were taking the blimp in. The wind was down hangar but it was 25 miles per hour velocity. The hangar door was just big enough to admit the ship. The ship was tied to the docking rails by means of two rolling trolleys on each side. When the nose of the ship was just entering the door, a particularly sharp gust of wind hit the ship on the right side, breaking all the ropes holding there. The gust whirled the ship around completely (180°), tearing loose all cables and holding ropes. Then the ship floated upward and away with the pilot on board. An engineer jumped aboard at the last second and started the motors. A man was carried up hanging to the side of the car. The pilot pulled the man on board and the ship was flown for seven hours until the wind subsided enough to take the ship in the hangar at evening.

The Graf Zeppelin has become accepted as a success. I think if misfortune befalls her now and she becomes a wrecked airship, we shall surely continue to refer to her as a success in airship operations. Her crew must certainly be given credit for having made her a success. She has had several experiences, in which with an inferior crew she might well have been wrecked. It will be of interest to recall four of them briefly:

On a westward trip, crossing to America, when near Gibraltar, four of her five motors quit, leaving her with only 20% power; nevertheless, she returned under her own power, hundreds of miles, to safety and an airship hangar where new motors were installed.

At Los Angeles, California, on her trip around the world, she took off in a severe temperature inversion, and it appeared she was going to crash into high tension wires. By quick and skilful discharge of ballast she was lifted purely on Free Balloon principles at the last second, and in time to clear the obstacle.

Coming up from South America, she arrived at Akron, Ohio, during the night and with strong winds--squalls approximating 50 MPH blowing on the ground. Her commander receiving this information while still in the air, made his own weather forecast and estimate. The result was, he decided to remain in the air. A few hours later the wind subsided and the "Graf" made a very quiet and uneventful landing, and was put in the hangar without difficulty.

Again, quite recently, this ship arrived at her South American destination after crossing the South Atlantic, only to find her loading facilities there in the possession of revolutionaries. Arrangements were quietly made to land in another country where the ship's safety could be guaranteed. Who can say what would have been attempted by a crew not so well-trained in any of these or other incidents? The ship has had her full share of trouble, but has been expertly handled.

Just before launching the British Dirigible "R-100", the British were developing some high mast equipment. The old "R-33" was tied to the mast when an accident similar to that of the Shenandoah occurred. The ship was floated statically, and carried off the ground her tail ballast, which was an artillery limber. She carried this weight for several hours until conditions permitted her to land.

On a certain flight of the German airship "Bodensee" she hit a severe snowstorm. The snow was of the type that clings to the skin and the ship became so heavy she had to land. She was set down in a wood and tied up temporarily by her own crew. Captain Heinen stated that none of his passengers were aware of any danger until after he had landed, when he walked into the passenger compartment and announced they had landed.

Now we may say that without some sort of test as to the value of experience we cannot justly come to any conclusion as to what, in the same situation, "inexperience" would have done. I shall conclude these incidents with one where such a test accidently occurred. The Los Angeles airship was being taken out of the Lakehurst hangar for an important flight. She had just arrived in this country and the German crew were still with her. On this particular morning, an American officer was in charge of the actual "maneuvering out": The ground at the doorway was covered with ice. When about halfway out of the door, one of the windward trolleys, guiding her through the center of the doorway, caught. The approved maneuver, under ordinary conditions, was to release the trolley entirely and hold the ship with men, in the meantime rushing the ship out before she could swing to the leeward door and crash. The American officer started the normal action of rushing out. However, Captain Fleming (the German pilot aboard) took things into his own hands. He started four motors up on the side of the ship,--full speed ahead. The rudder was put hard over against the air blast so that the tail was kicked away from the door and the push of the propellers drove the ship back into the hangar, dragging the ground crew with her. To my mind, he undoubtedly saved the ship from what might have been and probably was the wrong maneuver. It was my privilege to have been on board. Captain Fleming did not seem to be unduly excited except that he forgot his "English" and "barked" his commands in German. Maybe that is the answer.