

HEADQUARTERS 1st BOMBARDMENT DIVISION

Office of the Commanding General

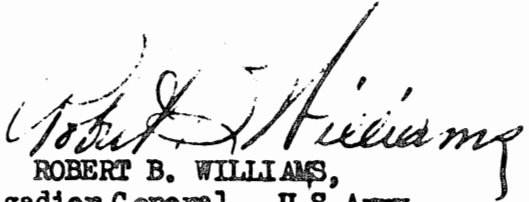
A.P.O. 634

SUBJECT: Formation Flying in the European Theater of Operations.

TO : All Combat Bomb Wing Commanders and Group Commanders,
1st Bombardment Division.

This study of defensive formation flying in the European Theater of Operations was prepared by a unit of this command, the 379th Bombardment Group, after one year of intensive operations in this theater.

The study has been reviewed by experienced combat leaders in this Division and it is their consensus that the tactical data contained therein is sound.


ROBERT B. WILLIAMS,
Brigadier General, U.S. Army,
Commanding.

FORMATION FLYING IN THE ETO

THE FORMATION WE FLY IS DESIGNED WITH THREE PREREQUISITES IN VIEW:

1. DEFENSIVE STRENGTH – THIS DICTATES THAT WE FLY THE MAXIMUM NUMBER OF SHIPS TOGETHER.

2. BEST BOMB PATTERN – THIS DICTATES COMPACTNESS AND THAT ONLY SO MANY SHIPS FLY TOGETHER AS CAN DROP BOMBS EFFECTIVELY ON LEADER'S SIGHTING.

3. EASE OF FLYING – THIS DICTATES THAT EACH PILOT OTHER THAN THE LEADER HAVE SOMEONE ON WHOM TO GUIDE. IT ALSO DICTATES THAT WE REMAIN WITHIN THE PERFORMANCE CAPABILITIES OF THE B-17.

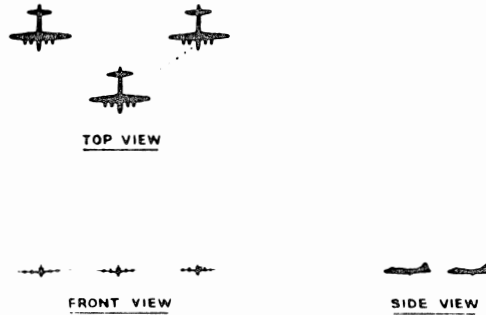
NOW KEEPING NO.3 (EASE OF FLYING) IN VIEW WE WILL BUILD UP THE FORMATION FROM AN ELEMENT OF THREE SHIPS TO A COMBAT WING OF FIFTY-FOUR SHIPS.

NORMAL
FORMATION

I NORMAL FORMATION

A. THE ELEMENT

The lead element (of all flights) looks like this:

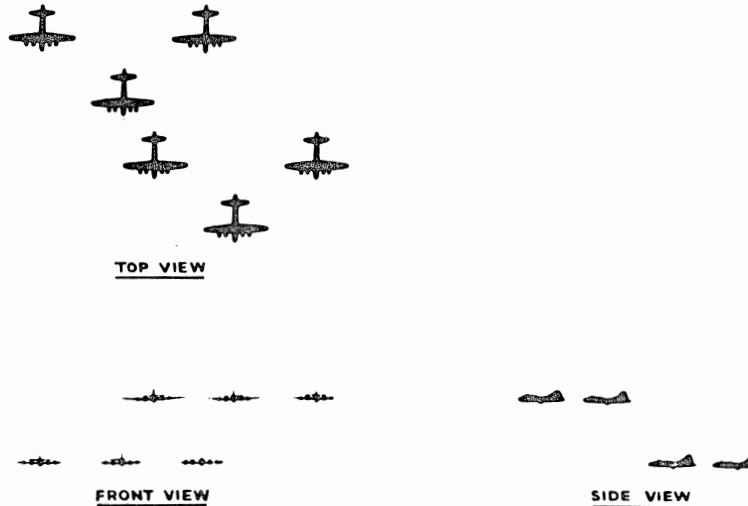


Wingmen fly level and guide along dotted lines which roughly bisect angle of leader's wing and fuselage. (This line will be called a "Wingmen Guide Line.") As a result the wingmen's noses clear the leader's tail and the wingmen's wingtips clear the leader's wingtips. Clearance is about 25 feet. All elements are flown in this manner.

I NORMAL FORMATION

B. THE LEAD FLIGHT

The lead flight is formed by adding one element called "The second element of lead flight" to the lead element as indicated:

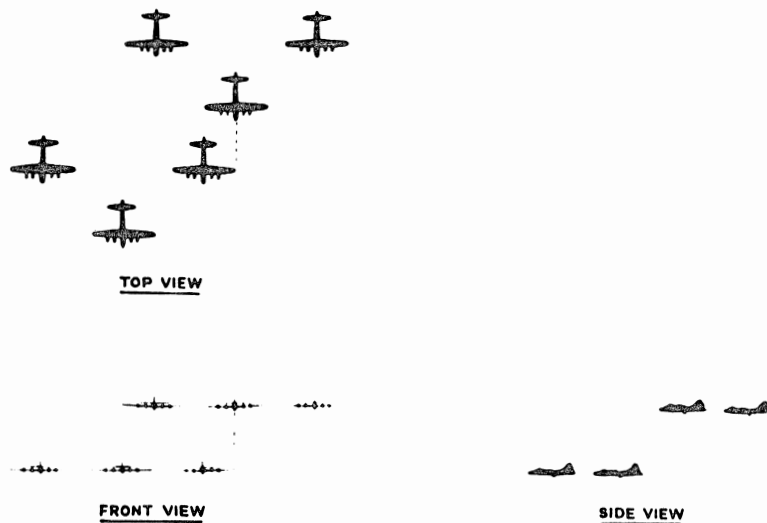


This second element of the lead flight flies below with about 75 feet downward clearance. The second element leader guides on the lead element right wingman's right wingtip as indicated by the dotted lines. He has about 25 feet rearward clearance. All lead flights are flown in this manner.

I NORMAL FORMATION

C. THE HIGH FLIGHT

The high flight is formed with two elements. The second element of high flight flying as indicated:

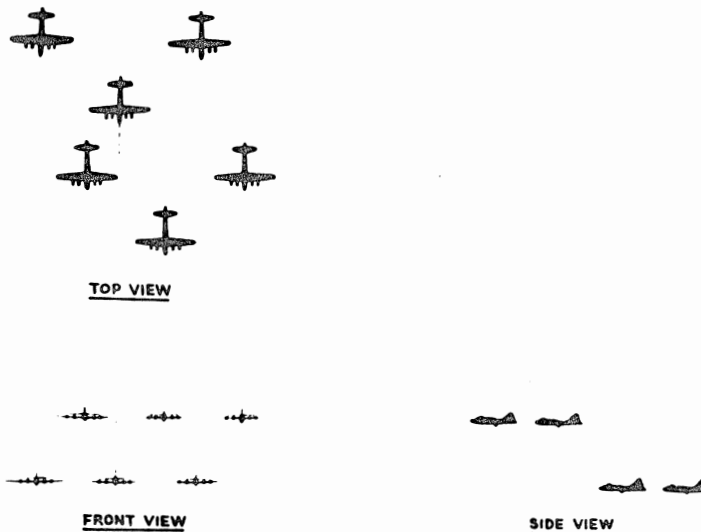


The second element of high flight flies above with about 75 feet upward clearance. He is directly behind the lead element's left wingman's left wingtip. He has 25 feet rearward clearance. All high flights are flown in this manner.

I NORMAL FORMATION

D. THE LOW FLIGHT

The low flight consists of two elements, the second element flown as indicated:

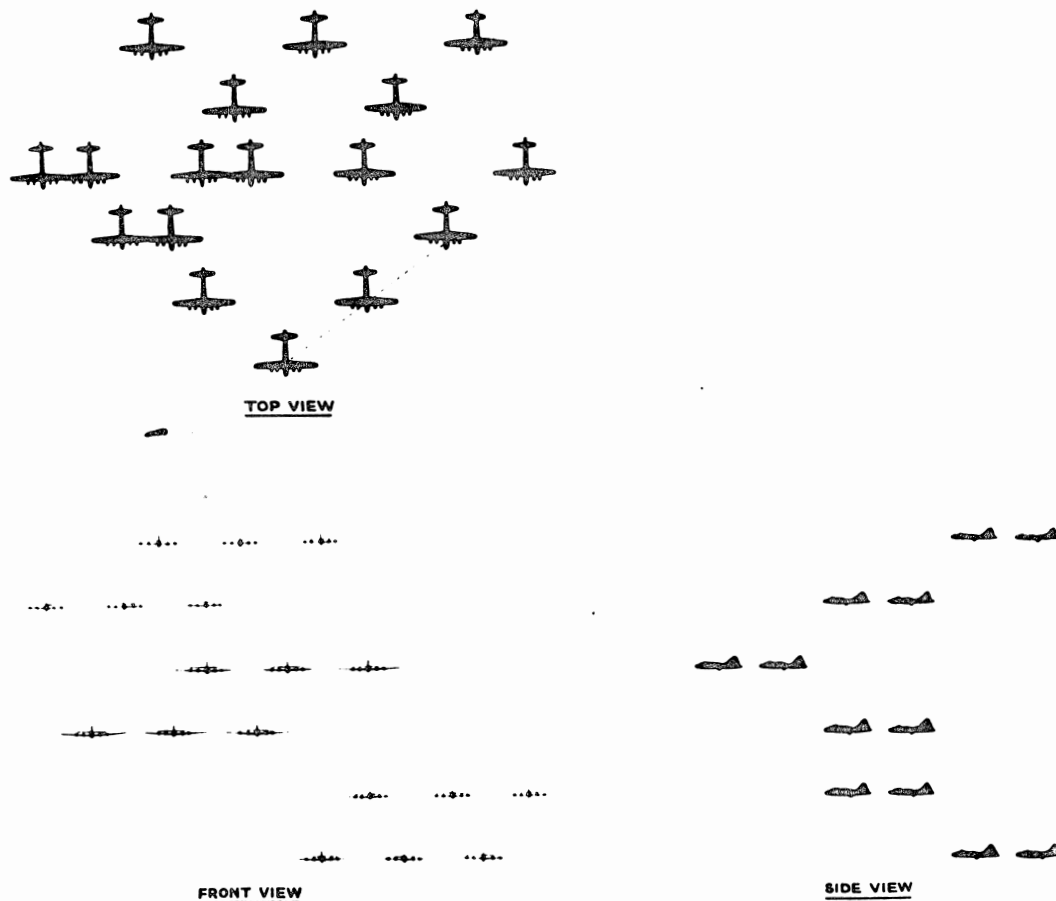


The second element of the low flight flies with about 75 feet downward clearance. The leader of the second element guides on the lead element's right wingman's left wingtip. He has about 25 feet rearward clearance. All low flights are flown in this manner.

I NORMAL FORMATION

E. THE GROUP

The group is formed by putting lead, high and low flights together. Add the high and low flights to the lead flight as indicated:



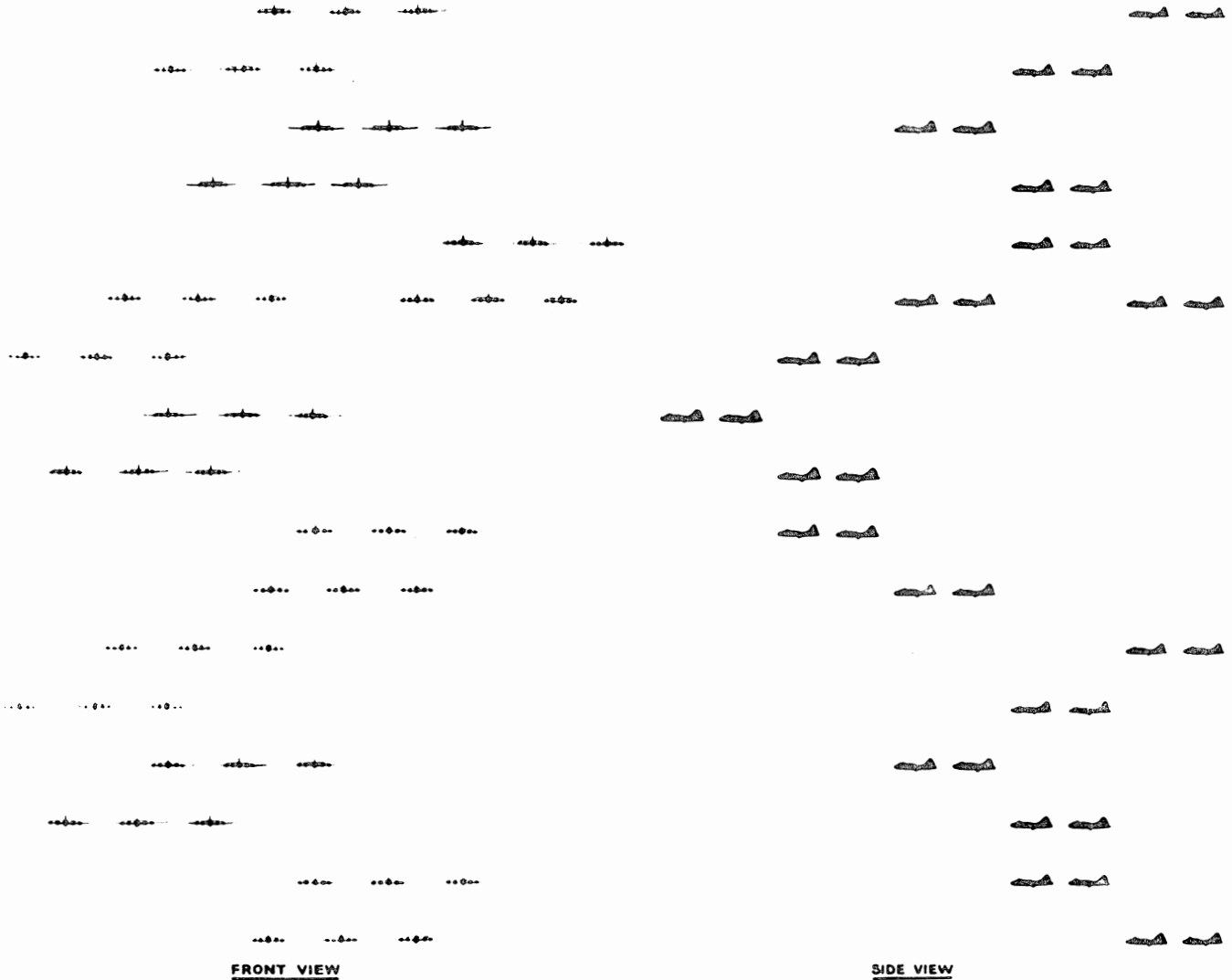
The leader of the high flight flies about 75 feet above level of the lead element of lead flight. He guides along 'wingman's guide line' on group leader. All high flights are flown in this manner.

The leader of the low flight flies below with about 75 feet downward clearance from the second element of lead flight. He guides along 'wingman's guide line' on group leader. All low flights are flown in this manner.

I NORMAL FORMATION

F. THE COMBAT WING

Place three groups together as indicated and we have the combat wing.



The low group leader flies directly below and to the rear of the lead group leader.

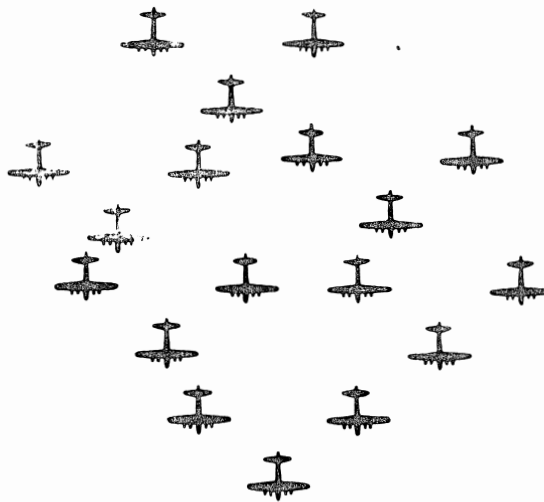
The high group leader flies above and to the rear of the lead group leader. He is also a little to the side away from the lead groups high flight, this in order that he can see the lead group leader.

VARIATIONS
IN
FORMATIONS

II VARIATIONS *in* FORMATIONS

A. GROUP FORMATION FOR BOMBING

During the bombing run the high flight must clear the units below. Then the group formation looks like this:



TOP VIEW

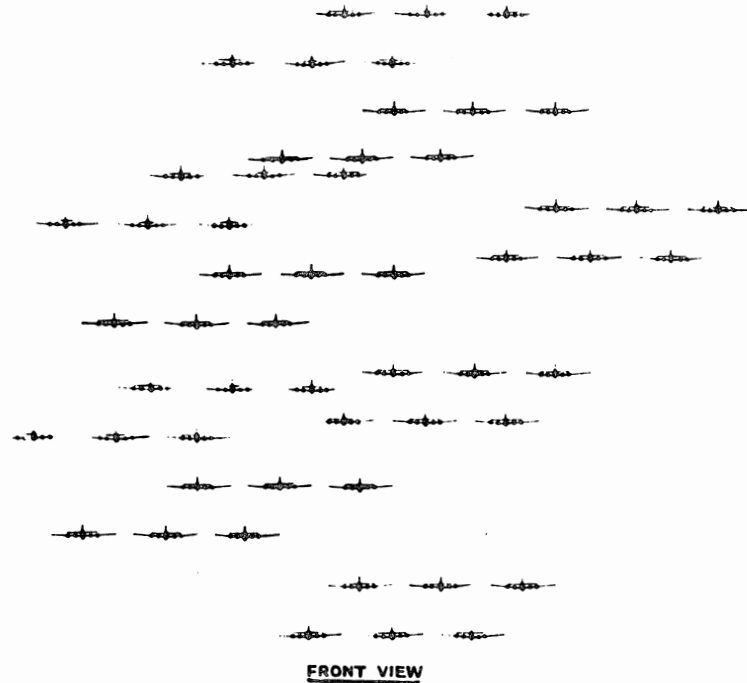


SIDE VIEW

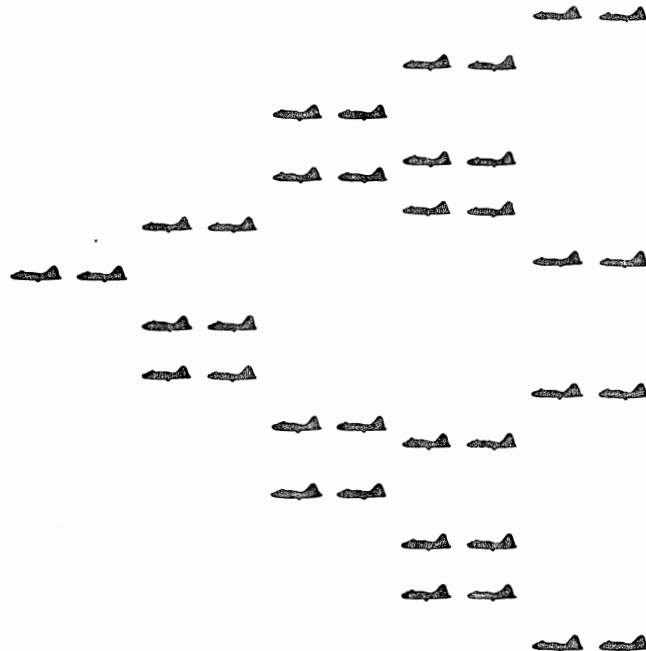
II VARIATIONS *in* FORMATIONS

B. COMBAT WING FORMATION FOR CLIMBING (AND CRUISING WHEN NOT UNDER FIGHTER ATTACK)

For the climb it is necessary to fly the combat wing with the minimum depth. Then the combat wing looks like this:



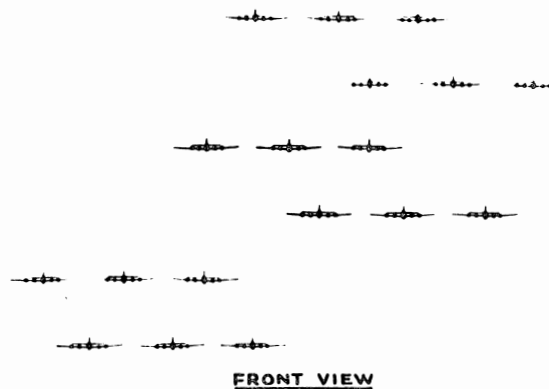
FRONT VIEW



II VARIATIONS *in* FORMATIONS

C. GROUP WITH SQUADRONS STACKED LEFT

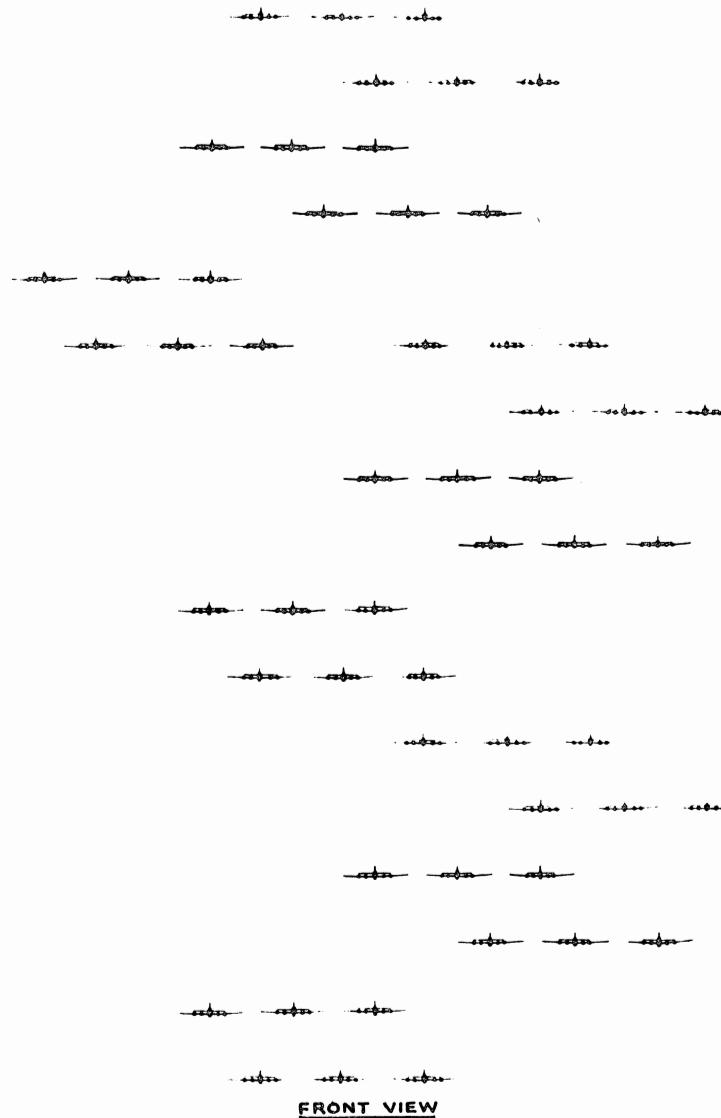
Flights may be flown in the "Stacked Left" position, in which case the group formation looks like this:



II VARIATIONS *in* FORMATIONS

D. COMBAT WING WITH SQUADRONS STACKED LEFT

When squadrons are stacked left the groups should be stacked right. Then the combat wing looks like this:

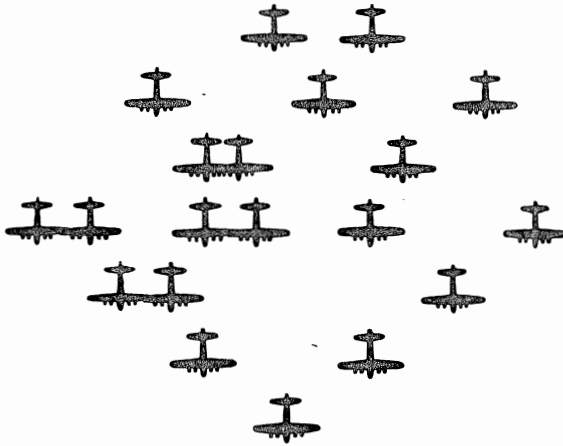


FAULTY
PRACTICES

III FAULTY PRACTICES

A. TWENTY-ONE AIRPLANE GROUP

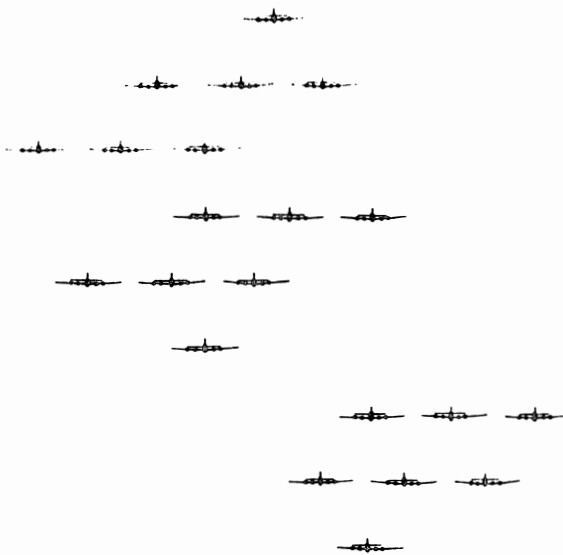
The twenty-one airplane group is used frequently in order to get more ships in the formation and more bombs on the target



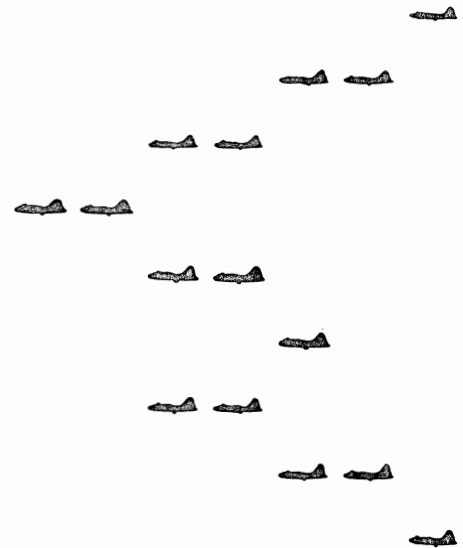
TOP VIEW

Faults:

- (1) Results in excessive depth of group and combat wing.*
- (2) Results in irregular bomb pattern which is difficult to predict and difficult to aim.*
- (3) Defensively weak with excessive straggling.*
- (4) Excessive number of abortives.*



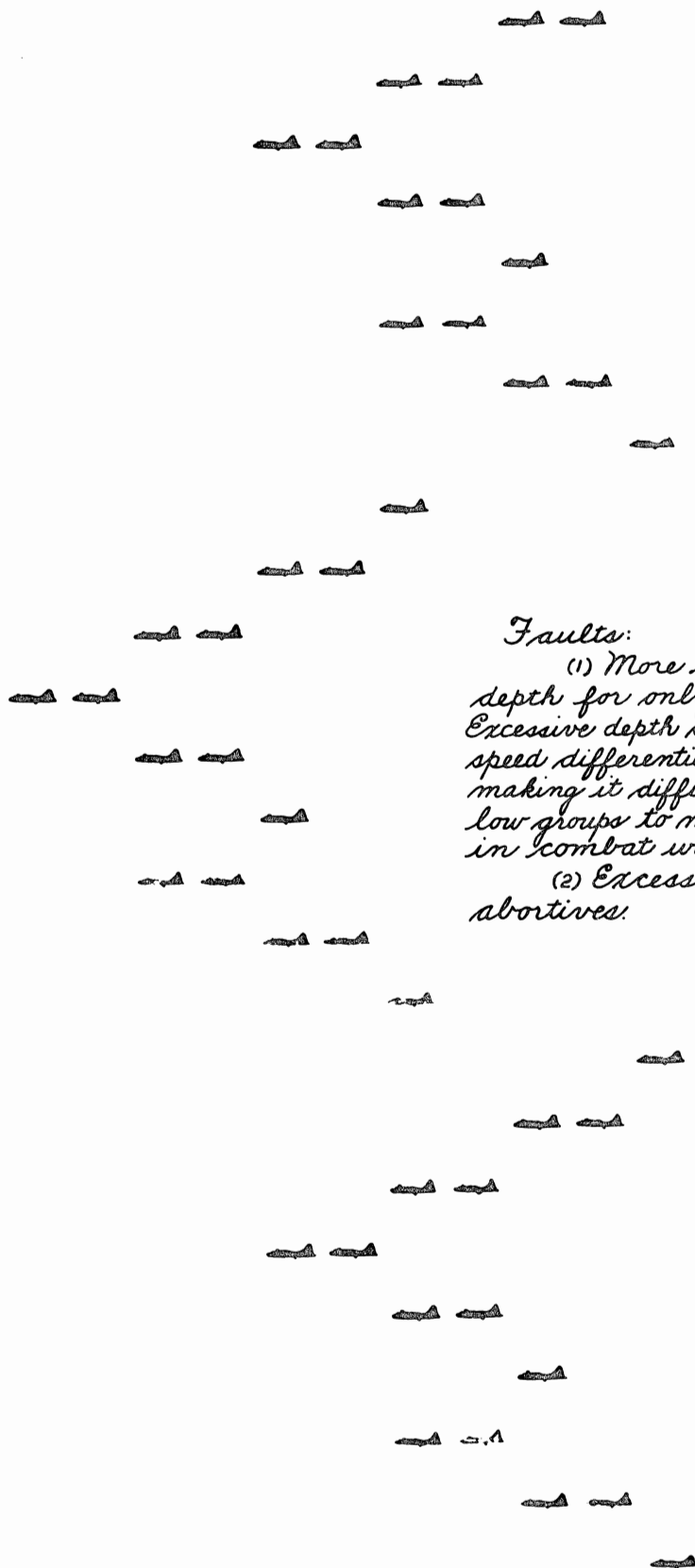
FRONT VIEW



SIDE VIEW

III FAULTY PRACTICES

B. SIXTY-THREE AIRPLANE COMBAT WING



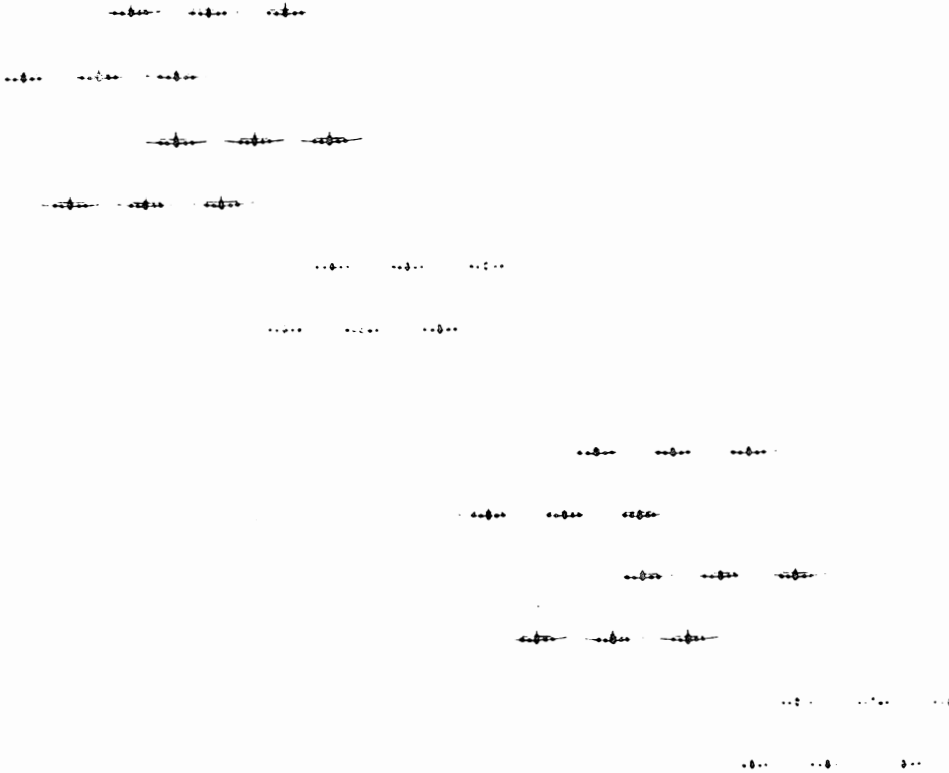
Faults:

- (1) More than $\frac{1}{3}$ greater depth for only $\frac{1}{6}$ more airplanes. Excessive depth causes large ground speed differential between groups, making it difficult for high and low groups to maintain position in combat wing formation.
- (2) Excessive number of abortives.

III FAULTY PRACTICES

C. COMBAT WING STACKED RIGHT WITH SQUADRONS STACKED RIGHT

Some unit commanders prefer to stack groups right so that leader of high group may sit in pilot's seat. The formation then looks like this:



Faults—

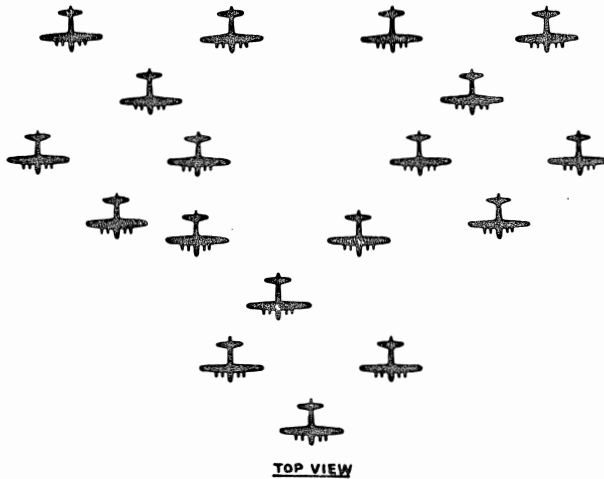
- (1) Combat wing flies with excessive depth.*
- (2) Defensively weak, for (a) mutual fire support is decreased (b) too many 'loose end' targets are presented for enemy fighters.*



III FAULTY PRACTICES

D. GROUP WITH WINGMEN STEPPED UP AND DOWN

At times it has been considered desirable to fly the formation with wingmen stepped up and down as shown below, the idea here being to uncover turret guns for head-on attacks and waist guns for side attacks



TOP VIEW

Faults:

- (1) Excessive Depth.
- (2) What is gained in uncovering of guns is lost in mutual support as result of depth, for more guns are placed out of range of attacking fighters.
- (3) Less easy to fly.
- (4) More self-inflicted battle damage.
- (5) Prohibits evasive action.



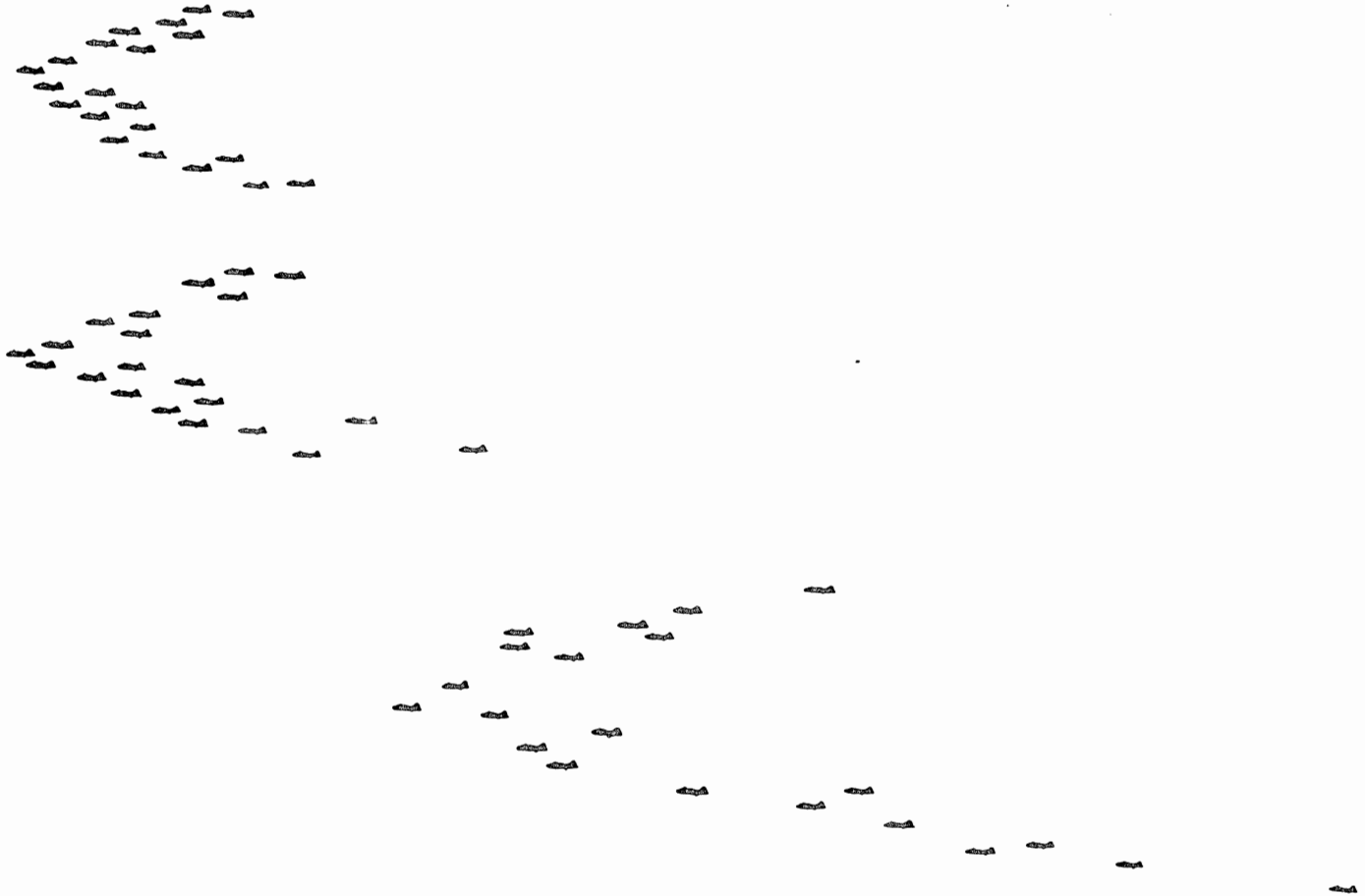
FRONT VIEW

SIDE VIEW

III FAULTY PRACTICES

E. APPEARANCE IN FLIGHT OF B., C., AND D.

When the combat wing is forced to fly with excessive depth as in B, C, and D above, it results in flight in the very weak formation shown below. This is caused by the normal variations in ground speed resulting from atmospheric pressure and wind differentials.



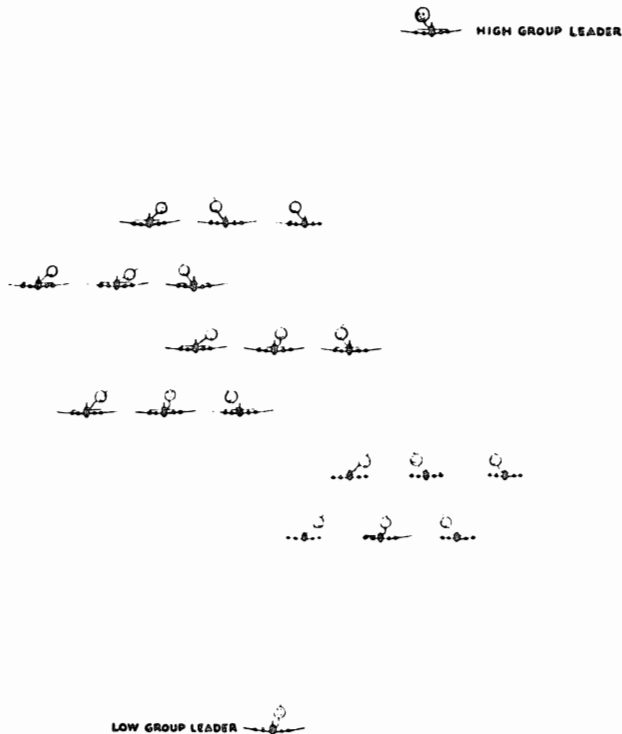
Many of these planes abort. Others wear out engines and cause future abortives. All are good targets.

INSTRUCTIONS
FOR
PILOTS

IV INSTRUCTIONS *for* PILOTS

A. COCKPIT SEATING OF PILOT AND CO-PILOT

The pilot always flies on the side of the ship next to his leader. This means that if the pilot looks out the right window to fly formation, he sits in the co-pilot's seat.



This is done (a) in order that the pilot may never lose sight of the leader during evasive action (b) for best possible formation.

Similarly the high group lead pilot normally sits in the co-pilot's seat and the low group lead pilot sits in the pilot's seat.

(Note - (1) Pilot always flies airplane when on the bombing run and when under fighter attack.

(2) Co-pilot performs evasive action by "taking the controls away from the pilot." Pilot watches leader and co-pilot watches instruments and enemy fighters.)

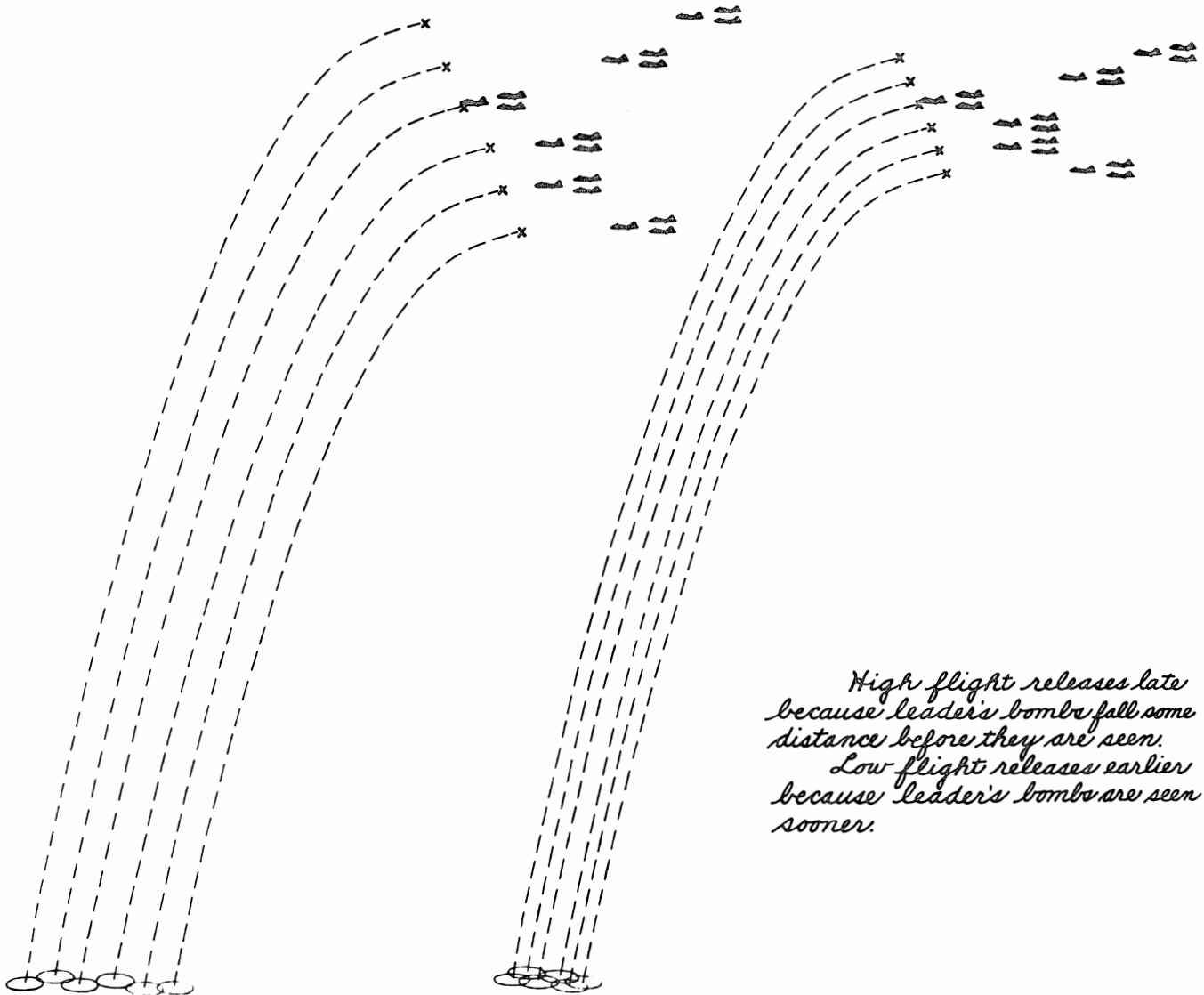
IV. INSTRUCTIONS for PILOTS

B. FORMATION ON BOMBING RUN

Flight and element leaders are cautioned to fly formation with minimum depth and maximum compactness on bombing run.

Note effect of depth on bomb pattern:

X - POINT OF BOMB RELEASE



*High flight releases late because leader's bombs fall some distance before they are seen.
Low flight releases earlier because leader's bombs are seen sooner.*

IV INSTRUCTIONS *for* PILOTS

C. BOMBING RUN

Groups in combat wing proceed on bomb run as indicated:



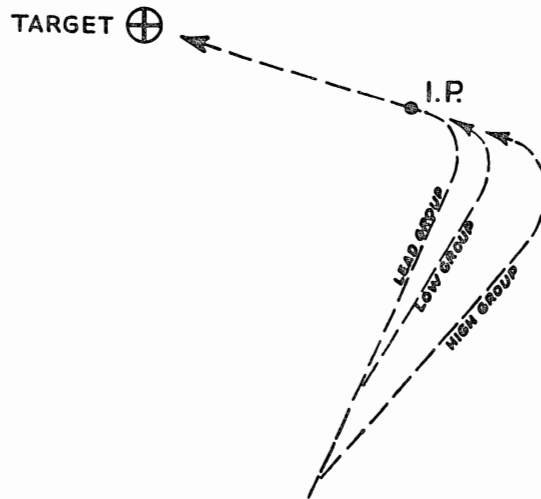
Low group takes little interval as danger of over-running lead group is negligible.

High group takes large interval as danger of over-running low group is great.

IV INSTRUCTIONS for PILOTS

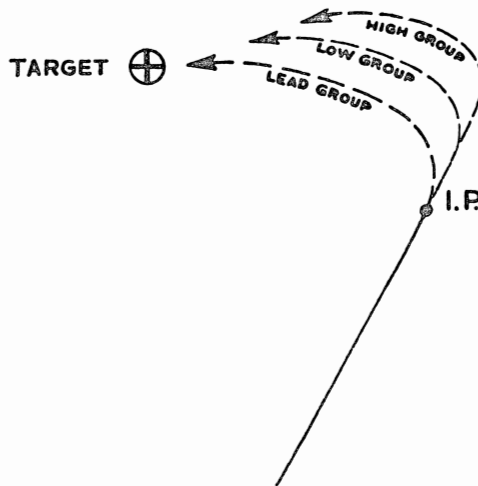
D. BREAKAWAY FOR BOMB RUN

Frequently the bombardier's major problem is to locate the target. Smoke screens and cloud cover add to this problem. To make the bombardier's work in this respect as simple as possible it is vital that groups pass accurately over the I.P. on an accurate D.R. heading towards the target. Hence breakaway for bombing is performed like this:



As an alternate method the low and high groups may assume bombing interval enroute to the I.P. and then follow lead group's track.

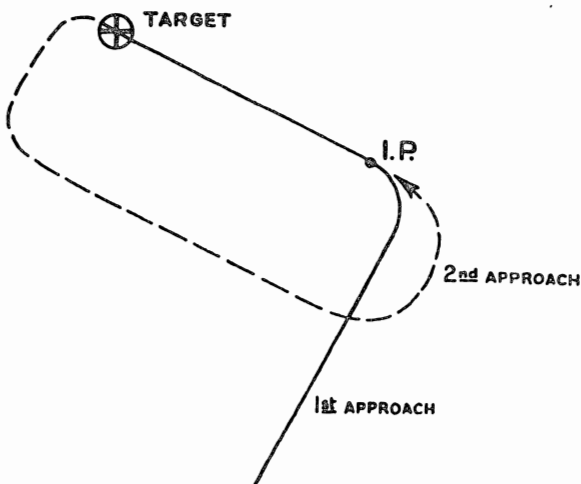
Breakaway should NOT be accomplished like this:



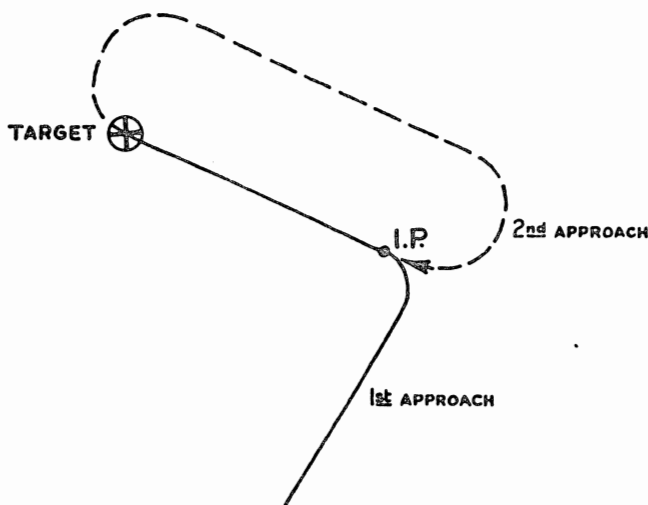
IV INSTRUCTIONS for PILOTS

E. SECOND RUNS

To get the most desirable second run, taking advantage of pre-set sighting data, best wind, minimum flak, etc; and to cause minimum interference with possible succeeding units, second run courses should be pre-computed so as to be flown on same heading like this:



or like this:



This method can be used where:

- (1) Target is located on first run but not in sufficient time for good synchronization.
- (2) Malfunction develops on first run.
- (3) Unit is cut off by some other unit on first run.

This method must not be used where cloud obscures target on briefed approach.

watch them to see when the rockets would be fired. Here again the enemy fighters would weep through our formation, would pick off the end ship or even whole squadrons at a time, and would often pass through without a single shot being fired at them by our gunners who were watching the rockets ships to the rear. The use of rocket ships by the enemy became a very severe morale factor when dispatching crews on a mission. Fortunately after the very heavy use of rockets on the Schweinfurt mission of October, the Air Force was able to dispatch Lightnings to escort our bombers on their next flight. Shortly thereafter the P-47 made its appearance, and later the P-51 the Mustang, which became the classic high altitude escort ship of the Eighth Air Force. These fighters were able to destroy the enemy fighter ships very readily, and except when the enemy used our contrail to cover them in approaching the formation, rocket ships proved more of a liability than an asset. Some air ^{to-air} bombing was attempted by the enemy sporadically throughout 1943 and 1944, but it never was considered a great menace and was abandoned finally. In meeting such attacks there was no way to modify the B-17 to do anything; the fighters did all the protection against the rockets, and the Germans air to air bombing was just no good.

In 1942, when the American heavy bombers opened their offensive against occupied Europe, the Germans knew no more about the B-17 than we knew about the German fighters. They knew it was a very heavily armed four engine bomber and treated it therefore with great respect. It was not until the very last few months of 1942 that the very heavy attacks against our formation began. Up to this time they limited themselves to making quick passes at the formation to discover what portion of that plane was most vulnerable to enemy fighter attacks. Because the B-17E was lightly armored in the nose, most of the enemy fighter attacks were directed against that part of the plane. This remained true until the installation of twin fifty calibre in the nose, and especially the installation of the chin turret in the nose of the B-17. From the very earliest months, and continuing until the end of the war, the majority of the fighter attacks were directed from above the ship, with the enemy plane coming out of the sun if possible. There was no way of arming the B-17 to prevent these attacks out of the sun. However the formations were so staggered that the lower ships in the formation were covered in small manner from these attacks by a great number of ships which were echeloned above them and away from the sun. These ships could cover the lower formations by use of their waist, ball turret, or upper turret guns firing down at the enemy fighters passing below. Attacks against the nose or tail positions could be met not only with the nose or tail guns, but also with the top turret or ball turret, depending whether the attacks came from above or below. Starting about September 1943, the Germans made use of twin engine rocket ships against our formations. These rockets would lie about two thousand yards to the rear of our formations, well beyond the range of fifty calibre fire, and would lob large rockets into the formations. They had the effect of scattering the formations, because a hit from one of these rockets was almost infallibly lethal.

With the twin engine rocket ships they also sent the customary single engine fighters that made quick passes at the formation as soon as they started to break up. When the rocket ships were in the rear of the formation, many of our gunners would

Escort problems affected the group formation as much as overcast bombing influenced the squadron formation. For, all this time, the escort range and number of our fighters were increasing, and more attention was paid to flying the bomb Groups in a way best calculated to aid fighter escort. Savings of width and height were effected in the three squadrons which flew as a group consisting of lead, high wing, and low wing squadrons. The effectiveness of this tighter formation and its fighter escort was established clearly in the smashing blows against the Luftwaffe in February 1944, which was rendered temporarily powerless by a series of knockout blows which reached all through the Spring of 1944.

The presence of the fighter escort meant a tremendous difference to the bombers. whereas before they had to fight their way, literally inch by inch on occasion, from beyond the shorter range of the Spitfires to their targets in Germany, now they had riding above them, or weaving a slow "S" through the formation, their own fighters, powerful P-47's or sleek P-51's, to take care of the German interceptors. It is not surprising that the pilots tended to relax their vigilance on the missions, sometimes flying their formations a bit too loosely to suit their fighter escort. At the meeting of the Group and Combat Wing Commanders in the Division, there was now a representative of the fighters, who could hear our problems, and present some of ~~our~~^{his} own. In one of these critiques of the missions in late 1943 the tactics of the Germans in their attempt to split our formations were thoroughly discussed. They would send Ju 88's, Me 109's, FW 190's, and any other types possible in their efforts to break up our attacks. The twin engine planes were sneaking in as close to the formations as possible under cover of our contrails, lobbing their rockets into the formation, trying to spread it, so that they would be more vulnerable to single

engine attacks. General Williams brought this situation to the attention of the fighter representative, asking him to inform the fighters that Jerry was sitting in our contrails in a position where we couldn't touch him, and that it would have to be up to the fighters to pick them off there. ²² This, of course, was not quite so simple as it sounded, because it meant bringing the fighters much closer to the formations under actual flying combat conditions than the fighters cared. Many a trigger-happy gunner took a shot at a p-51 or P-47, mistaking them for Me 109's or FW 190's. But the fighters took care of the formations, even when it meant quite a risk for themselves, escorting the formations to such distant targets as Berlin, giving them cover all the way in and out. So great was the range that on one mission they actually flew ahead of the bombers and gave support to the Russians on the Eastern Front.

It was a matter of concern for both the fighter pilots and the Commanders of the Heavy Bombers to learn that some of the Squadron were breaking away from the Combat Wing as they approached the coast. They had adequate fighter cover at the time, but it was noted that they were playing with fire to relax even the slightest over enemy territory, even over the sea on the way back, the situation was called to the attention of the commanders of the Groups and Combat Wings to have it corrected. There were enough conditions that tended to break up the formations without adding carelessness to them. Often icing conditions made the formations break up over enemy territory, and very accurate flak had the effect of at least loosening the formations when the lead pilots tried to take evasive action. For a long time it was thought that the Germans could fire only a barrage type of flak through complete cloud cover, but it was soon noted that the Germans

were doing sort of continuous following fire instead, fire that became exceedingly bothersome.

Gasoline and Oxygen shortages contributed to the breaking up of the formations also. On one mission there were reports of single ships breaking out of the formation over the target in attempt to get home because they were low on gas. Trying to get home alone was non-habit-forming in the extreme. And if a plane was out of oxygen, the pilot had no choice but to leave the formation and fly at a lower lever...on deck, if possible.

XII

The final stage in the development of combat tactics in heavy bombers came in 1945. By that time the Luftwaffe was no longer a serious threat. Lack of fuel and experienced pilots had reduced it to a mere shadow of its former formidable self. As the bombers' hours and sorties multiplied, the bomber losses and fights dwindled. Fighter cover had supplanted bomber fire-power as the first line of defense, and our fighters controlled the sky over Germany through which the bombers flew day after day.

Because they could no longer rely on the Luftwaffe for defense, the Germans tightened their flak defenses, and this became the prime problem. The need now was for a formation that could be easily escorted, still bomb targets effectively, but do that in less time and with ~~less~~^{less} exposure to flak. Thus was developed the normal 27 aircraft group, composed of three nine-ship squadrons, increasing to thirty-six aircraft when a fourth low-low was added. ²³ (see diagram)

22 Combat Wing and Group Commanders Meeting, 3 December 1943, p.5.
23 Tactical Developments, pp. 32 & 33.

The new nine-ship squadron was superior to the twelve aircraft squadron in that it increased cohesion in the individual unit, and clearly afforded more flexibility. The smaller formation was easier to control and easier to fly. It was possible now, with less confusion, to obtain better results in the bomb pattern and reduce per-plane exposure to flak. The bombing results achieved and the ~~losses~~ ^{rate} sustained were so satisfactory that the twenty-seven or thirty-six plane formation was used to the completion of the war as the final product of our work on combat tactics.

APPENDIX

Developments in the Physical Aspects of the B-17

The first B-17 that was used in combat was the B-17D, used against the Japanese in the Pacific theatre of operation. The B-17D differed from all later models in that it had no tail position to fire from. From the earliest reports from the Pacific theatre, it was apparent that there was a great need for a tail gun position on the B-17. So, the B-17 was modified into the plane that we knew as the B-17E.

The 97th B.G. Heavy, the original bombardment group in the E.T.O. was the first to use these B-17E's, and the armament on the plane was as follows: the nose of the ship had only one gun, a thirty calibre machine gun, that could be moved from one position in the nose of the B-17 to any one of four sockets. It was hand held, with a ring and post sight, a thirty calibre machine gun, movable, firing through any one of four sockets in the plexi-glass nose. Later the 97th Bomb Group modified this mount, so as to have the thirty calibre machine gun mounted on a ball-and-socket-mount, firing from one of four positions in the nose of the B-17, but it was not movable from the eyelet in which it was adjusted to any other of the four eyelets. In addition to the thirty calibre nose gun, the B-17 had also twin fifty calibre machine guns in its upper turret, twin fifty calibre machine guns in a lower or ball turret, two fifty calibre machine guns mounted on either side of the waist, and twin fifty calibre machine guns in the tail which were not operated on a power turret. The 97th Bomb Group used these first B-17E's on the first mission against occupied Europe on August 17 1942. They were used on the succeeding missions of August and on some of the missions of early September. But in the late part of the month of September the B-17E's of the 97th Bombardment Group were replaced by newer B-17E's of the 92nd Bombardment Group then

stationed at Bovington.

The 92nd Bombardment Group had arrived in England the day of the first bombardment mission against Europe. They also were equipped with B-17E's, but they had some extensive modification on their planes while yet based at Sarasota in Florida. The most important modification came in the form of nose mounts for the guns and the restringing of ammunition throughout the gun positions on the plane. In this group they had removed the thirty calibre machine guns from the nose, and replaced it by either one of two mounts. In some of the ships a single fifty calibre machine gun was mounted dead center on a ball and socket mount, giving it a very good range in covering attacks on the dead center of the plane. In others they had replaced the original mounts by two fifty calibres, one mounted in a forward position to the right and one mounted in a rear position to the left. Although this double mount had the advantage of covering more space than the single fifty calibre in the center of the nose, it had the disadvantage of requiring two gunners to operate them effectively against all head on attacks.

In the original B-17E, the nose guns and some of the guns in the other positions were fed by boxes of fifty calibre bullets that held from thirty to fifty rounds. In place of these, the 92nd Bombardment Group restrung the ammo on belts in the waist guns and in the nose position, feeding the guns from boxes that held up to six hundred rounds. In this group also experimental work was done in mounting a single fifty calibre machine gun above the radio man in the radio compartment of the B-17. This was not completely developed in that group, but some of the original work was certainly done by the 92nd.

The upper turret of the B-17E was scarcely changed by any later modification. It had always been considered one of the two best gun positions on the ship, and until the last days of the war, it was

Considered, with the ball turret, to be the best firing position on the B-17. The waist guns position were different. In the original B-17E the waist guns were single fifty calibres that fired through open windows. When the gunner was ready to fire, he opened the side panels, pulled the gun mount out and fired. This, of course, let a great blast of air through the whole waist of the B-17, and the tail gunner was the principal recipient of this cold wind. With the limited equipment at their disposal, the early groups in the E.T.O. were unable to modify this position on the B-17.

The projection mount of the waist gun ~~was~~^{was} originally located approximately six inches inside the skinline of the fuselage of the B-17. This greatly reduced the field of fire due to the limited size of the open waist window. So, in February 1943, work was begun in the E.T.O. to modify this mount, relocating the waist guns in a position nearly flush with the skinline of the fuselage. The modification so carried out allowed a greater azimuth of swing and greater downward deflection of the waist guns, making them much more effective in warding off enemy fighter attacks from both sides of the waist gun position. The final modification in this waist gun position was the changing of the waist gun ammunition cans from those that held only two hundred rounds to those which held six hundred rounds. The tail gun position on the B-17E was about as satisfactory as that of the upper turret, and no work was done to modify this position until well into the next year. During the spring of 1943 it was decided to replace the ring and post sight of the tail gun with the N-8 optical sight. The actual change in the sight was incorporated in the aircraft assembly line, and it proved most satisfactory in the tail position in warding off enemy fighter attacks from that direction.

When the bombers started their missions against occupied Europe, many of the problems which had remained theoretical up to that point

became very practical. From the first three or four months missions, it was possible to determine what sections of the B-17 were most vulnerable to enemy fighter attacks and work done was designed to reduce this vulnerability. In the 92nd B.G., Major Robert Reed, commanding officer of the 327th Bombardment squadron, went to work on one ship to modify it in such a fashion that it would give an ideal covering of protective fire. He started the work on this ship at Bovington in England, but was eventually sent back to Wright Field in the United States to complete that work. By the time he had finished his modification, the B-17F and G were coming off the assembly line in great numbers and his modifications were never incorporated in the plane. In place of the original nose mount of the B-17, Major Reed took the tail turret of the B-24, and had that installed in the nose of the B-17. The result, of course, was a severe change in the aerodynamic structure of the plane. It was necessary, therefore to compensate for the increased drag in the air by reducing the armor and armament throughout the plane. Eventually Major Reed took his modified B-17 back to the E.T.O. to show it around, but it was never flown on any operational missions after he had completed his work.

When the 91st, 303rd, 305th, and 306th bombardment groups came to England in the late months of 1942, there were a sprinkling of B-17F's in those groups. In the late months of 1942, and early months of 1943, all the B-17E's in the theatre were replaced by the newer B-17F's. Many of the modifications that had gone into the B-17E appeared on the assembly line incorporated into the B-17F. In particular the nose guns were not thirty calibre movable types, but were located on ball and socket mounts in the eyelets either dead center or to the right or left of the nose position. In some of these B-17F's there were two fifty calibres mounted as a twin set in the dead center to give an even

greater fire power to the nose position. There was too, a fifty calibre machine gun very clearly located in the compartment of the radio operator. Again, like the waist gun, the fifty calibre gun in the radio compartment fired through an open window in the top of the ship, and added to the tremendous air current running through the plane at high altitudes. As a result of these open positions on the ship, there were numerous cases of frostbite, so, in 1943 work was started to modify the central portion of the B-17 to inclose both the waist guns and the radio guns, thereby protecting the men inside the ship from the severe cold encountered at very high altitudes. Often this cold reached from fifty to fifty-five degrees below zero. By the end of 1943 the radio compartment had been closed, and the guns mounted in the plexiglass of the radio compartment hatch. By the end of 1943 closed waist gun windows were procured from Z of I, were mounted on the B-17, and the waist guns were mounted in the central section of the plexiglass. It was possible thus to reduce the number of frostbite casualties without reducing the effectiveness and fire power of any of these positions. This, of course, had very beneficial effects on the waist, tail and radio gunners, and also reduced the number of casualties on operations from noncombat reasons.

As the range of B-17 operations in Europe extended beyond fighter protection, it became apparent that some means must be taken to give extra protection to the bombers while on their missions, and to that end a plane known as the YB-40 was developed in the United States to give long range escort to the B-17. The YB-40 was, actually, a B-17 that had been modified. In addition to the turrets and other gun positions of the original B-17, this YB-40 had a chin turret mounted in the nose, this chin turret being similar to that which was later installed in the B-17G. It had also, two pairs of direct sighting,

power-boasted twin fifty calibres on each side of the waist compartment, twin fifty calibres mounted on an additional martin electric turret in the radio compartment, and twin fifties in a power-boasted tail gun mount with a reflector sight. This plane carried forty thousand rounds of ammunition and was designed to act as a four engine fighter escort. Actually, the weight of the plane was so tremendous, close to seventy-two thousand pounds on take off that the ship proved extremely poor in combat. It was not as manoeuvrable as the B-17, and the defects in the boosting system of the ammunition as well as the very great strain on the hydraulic system of the ship made it impossible to fire all turrets at once while the plane was in the air. After using this plane on about ten or twelve missions, the project was abandoned. It was flown by the 327th Bombardment squadron of the old 92nd Bombardment Group from Alcombury, just outside 1st Division Headquarters in England.

Before the project was abandoned, extensive efforts were made to correct the defects of this ship, principally under the direction of Lt. Robert Leveridge of the 327th squadron. But his attempt to correct the defects of the ship were so unsuccessful that it was, as before mentioned finally abandoned completely.

From the very earliest missions it had been apparent that something must be done to increase the effective range of the B-17 if the Americans were to carry their offensive to the choice targets that lay deep in the heart of Germany. To increase the range of the B-17, therefore, the Tokio tank was developed to be installed in the wing of that plane. The Tokio tanks were a series of small or slightly larger gasoline tanks that were installed in the leading edge of both wings, extending from the fuselage all the way out to the wing tip. These increased the range of the B-17 so much, that instead of attacking such targets as St. Nazaire or Romilly in France, they were able later

to fly deep into Germany and even as far as Gdynia in Poland and still return to their bases in England.

At the end of the summer of 1943, the B-17G made its appearance in the E.T.O. The B-17G differed from the B-17F in two principal respects. First of all in place of the original mounting of twin fifties in the nose, there was a power operated chin turret that was very effective in handling head on fighter attacks. In addition to the chin turret, there were mounted on some of the B-17G's, one mounted forward to the right, one rear to the left of the nose position, two fifty calibre machine guns. Secondly, the B-17G had the Tokio tank already installed in the wings, and were prepared to fly on very long missions. At the end of 1943 the Americans began their real offensive against the targets in Germany proper, the offensive that had started with their first attack on Germany on January 26th 1943 when Wilhelmshaven, the great German naval base was bombed. In the great raid on Schweinfurt in October 1943, the planes used were mostly B-17F's. This mission proved conclusively that it would be too expensive for our heavy bombers to penetrate deep into Germany without adequate fighter protection, for it did not seem possible for the heavy bombers to take care of themselves on these long missions, no matter how heavily armored they might be. Shortly thereafter the fighter groups began pouring into England to escort the heavy bombers on their long missions into ~~Germany~~ ^{Germany}.

With the fighters came more groups of heavy bombers, and these groups came already equipped with the B-17G's, the final product of the Boeing assembly line. In the latter part of 1943 there were many missions flown in which B-17G's flew with B-17F's. Trouble developed shortly thereafter. Probably the classic example of this was the mission to Stuttgart when well over twenty of our bombers ditched in the Channel because of lack of gas, caused by the fact that the lead

ship had a great deal more gas in it, and kept the formation over Germany while the leader looked for a target of opportunity to bomb. Most of the lost ones ran out of gas just after passing the French coast, and they were fishing men out of the Channel for the next two days.

There is no doubt that the B-17 was aided considerably by the additional changes in the E.T.O. and by the changes made on the aircraft assembly line, but it was still necessary to escort the formations by fighters when they made their penetrations deep into Germany. In particular this was true against such targets as Schweinfurt, Meresburg, and Berlin. The attacks on Berlin started in the early part of 1944, when in February a force of about seven hundred bombers went to attack that city, so often hit by the RAF.

During the late months of 1943, when the targets in Germany had been hit by our heavy bombers without adequate escort, it had become customary for the gunners to carry a superabundance of ammunition to make sure that they never run short while under enemy fighter attack. With the fighter escort of 1944, however, the number of enemy fighter attacks against our formations decreased considerably. And in the late months of 1944, and early months of 1945, the fighter attacks against our formations just about disappeared completely. Some of the pilots, however, and in particular, some of the gunners, who had been there in the early part of the war, still had the phobia of German fighters very clearly present in their mind, and they continued to bring the tremendous amount of ammunition that they had to carry in the late months of 1943. At a staff meeting held at headquarters of 1st Division, therefore, this situation was called to the attention of the commanding Generals of the Combat Wings and the commanding officers of the groups. It was suggested but not necessarily directed that the gunners bring a maximum of six hundred rounds per gun position on the plane. This was considered to be the average number of rounds fired by a gun position under fairly heavy fighter attack. Many of the gun positions actually carried considerably more, but it became S.O.P. to carry six hundred round boxes of ammo per gun position after about March 1944.

The second squadron flew about two to three miles behind the lead squadron at approximately the same altitude and in the same formation. This separation of squadrons did not give much chance for mutual fire support, but, fortunately for the men flying the planes, the German interceptors treated the bombers with a great deal of respect, did not press home attacks sufficiently to wipe out the small force sent out on this and some of the succeeding days, so the casualties on the early missions were by no means as high as an alert defense should have brought about. For this mission to Rouen and for the succeeding ones within range, Spitfires of the Royal Air Force gave good cover. But even with the top-cover thus afforded, the Germans should have been able to concentrate enough interceptors in the area of France to annihilate the whole force on each of the early missions, and might have killed daylight bombing before it really got started. They failed to do so, however, and by the time they went to work on our formations in real earnest, we had grown big enough to take care of ourselves pretty well, had become too big to be wiped out.

Succeeding forces flying out of England in 1942 saw up to four squadrons of each group flying wide apart, as in the following diagram.

These missions were covered by the RAF spitfires, except on missions to Lorient and St. Nazaire, where the bombers outranged their Royal Air Force escort. In the latter case the fighters gave escort part of the way and gave withdrawal support on their return trip. The formation thus flown had great flexibility, but the mutual fire support from squadrons was just about nil. Enemy fighter attacks were met by each squadron alone, unless the fighter escort was there at the time, in which case they had good fighter support, but fire from other squadrons did little to ward off the enemy.

IV

When the German U*Boat Campaign became dangerous to Allied shipping, the range of attack of the B-17 was extended, and the Eighth Air Force began to fly well outside range of escorting fighters to attack submarine bases in Holland, France, and Belgium. By this time the Air Force in England had grown to include the 91st, 393rd, 305th and 306th Groups with B-17's and the 93rd and 44th Bombardment Groups with B-24's. ¹⁰ The 97th and 301st Groups which had arrived early in the operations were pulled out for North Africa invasion and never were returned to the Eighth Air Force in England. And as the power of the Air Force -- or rather Bomber Command, as it was called-- grew, the strength of the German counter-attacks against our formations also grew. They had, apparently, determined that the Flying Fortress was not quite the fortress they had expected to find, and their attacks became more aggressive on each mission. Most of the time the bombers had to fly beyond the escort of the Royal Air Force Spitfires, and we had no F-38's or P-47's to fly further with our own bombers. It was not until late the following year 1943, that long distance escort was provided.

¹⁰ Cf. History of 1st Bomb Wing, Chapter one and two for discussion of times of arrival of various bombardment Groups in 1942.

The growing power and aggressiveness of the Luftwaffe in 1942's final months dictated the necessity of compression of the previous loose formation of four squadrons flying far apart with no ability to render mutual fire support. In order to make this mutual support and concentration of fire power possible, two basic formations were developed, the 18 aircraft group and the 36 aircraft group.

The eighteen aircraft group, consisting of two boxes of nine aircraft each, was designed to permit better control of more aircraft. In this formation each squadron was a "V" of three elements, and each element a "V" of three aircraft. The nine aircraft in each squadron flew at the same altitude, with the wing element in trail of the lead element. The second squadron of nine aircraft flew five hundred feet above the first, slightly in trail, and echeloned away from the sun. The following diagram represents the outline of the 18 aircraft group.¹¹

□ Tactical Developments: p. 8.

The development of the 18 aircraft formation was step in the right direction. It was an attempt to put the aircraft in a more compact mass, thus enabling a much larger unit to fire on enemy aircraft coming in for attack. It was a much more compact formation than the original Rouen formation, but had less flexibility than it. On turns the wing aircraft often lost sight of those in the center of the formation during the completion of the manoeuver. As previously mentioned, the whole of each squadron flew at the same altitude, and because the unstacked elements blocked out each others field of fire, vulnerability to German Fighter attacks from certain angles was increased.

VI

The development of the 36 Aircraft Group at the same time as the development of the 18 Aircraft Group is clear evidence of the growing concern of the commanders in the 1st Wing in getting the aircraft bunched into large units for mutual protection. This alternate formation was a further step in the direction of more mutual support and of more unified control of the planes of the missions. It had three units of twelve aircraft each. The units were further broken down into four elements of three aircraft each. The formation had the apperance in flight: 12 (see diagram)

12 Tactical Developments: pp. 10 & 11.

The inner aircraft of the formation were well protected, but it did not solve the problem of flexibility, and the increase of fire power was not very notable. And the formation was a very difficult one to fly. The two trailing elements of the formation were required to be abreast of each other with all six aircraft eighty feet below the lead elements. The trailing elements were echeloned toward the sun from the lead elements. It did, however, solve the problem of staggering. In this formation, three units of twelve aircraft were staggered as follows, the lead unit, a second unit flying right wing to the rear about five hundred feet above the leader, a third unit flying left wing still further to the rear and about a thousand feet above the leader. Although this type of formation kept as tightly closed as possible, the lead aircraft flew out of the line of vision of many of the planes, making a really cohesive formation virtually impossible.

VII

Javelin of Group of 18 Aircraft Each.

As the size of the Division grew in the end of 1942, the targets within range of the bombers, but still not hit by daylight, became more of a problem, and in the beginning of 1943, Rommilly in France and Wilhelmshaven in Germany were scheduled to be added to the target list. But because this increased the time of exposure to enemy fighter attack, and because ^{most} ~~most~~ of the mission would be protected only by the fire power of the bombers themselves, the development of a formation affording a maximum of mutual fire support was necessary.

In December 1942, therefore, the first standardized javelin formation was developed, consisting of three squadrons, lead, high, and low. The squadrons comprised two elements in echelon, each element stacked toward the sun, with elements and squadrons similarly stacked.

The formation thus took on the following appearance.. (see diagram) 13

13 Tactical Developments: pp. 13 & 14.

This formation increased the flexibility, brought greater fire power to bear within each group, but did not significantly help forward fire power. The Luftwaffe, of course, exploited the vulnerability of the lightly defended nose position, and was able to cause losses ranging from ten to twelve percent by the end of the winter. To attempt to deny the enemy his best line of attack, the groups were flown in trail, stacked above and behind the lead Group, and echeloned toward the sun. In doing this, the groups became separated beyond the range of mutual fire support, but at least the column effect provided some denial to the enemy's freedom of attack.

The chief disadvantage was the difficulty of flying the formation. When the elements were stacked in trail, the differences in altitude between the highest and lowest elements caused a very troublesome speed differential, necessarily consequent to the wind differential. This resulting in the "stringing out" of the formation, and abortives mounted as individual planes were unable to maintain their position in the formation. The increase of abortives, cutting down the size of the formation, resulting in a very notable decrease of mutual fire support, so the javelin of the eighteen aircraft was abandoned at the end of 1942. 14

14 No attempt is made here to give specific missions to support the statements that the Luftwaffe attacked the nose position most frequently or to support the statements on the number of abortives. Some picture may, however, be gotten by the reader choosing individual mission folders at random from this period, and almost invariably the statement will be borne out by the contents of the folder.

VIII

In December 1942 General Kuter took over the command of the 1st Bomb at Brampton. He remained at that headquarters for just one month, but in that one month he managed to do quite a bit of work. When the present writer went to Brampton to work in the early part of 1944, those who had been there in the time of General Kuter still spoke of his tremendous knowledge and energy....and commanding Generals don't usually leave such a vivid impression after only one month at headquarters unless they are very exceptional men. One of his final acts before relinquishing the command of the Wing was to create two Combat Bombardment Wings, the first ones organized in England during the war. The Combat Bombardment Wing was the proverbial "N" th product in the attempt of giving unification to the aircraft on a mission.

Before the actual introduction of the Combat Wing formation, however, another attempt was made to solve the difficulty of a unified formation by flying the Wing as a wedge of five Groups. The wedge formation replaced the Javelin in an attempt to stop "stringing out" in column. To give the five Groups some unity, the lead Group was placed in the center, with two groups echeloned above, and two below in opposite echelon. In flying it, the squadrons, and groups, were stacked in the same direction. In flying it the layout of the five groups was as follows. ¹⁵ (see diagram)

15 Tactical Developments: pp. 16 & 17.

With this formation the column of bombers was shortened considerably, but it did not entirely overcome the tendency to string out caused by the difference in altitude between the highest and lowest groups. It did, however, reduce the speed differential between the lead and trailing groups by placing the leader in the center at mid-altitude, it did reduce the vulnerability of the formation to fighter attack, adding considerably to the forward fire power of the bombers giving mutual support. But though the formation cut down the losses and further compression of the groups was found necessary to give even greater forward fire power. The resulting formation was the first combat wing, the wing composed of fifty four aircraft.

IX

By March 1943 the problem of stringing out had become so bothersome that a unit was developed consisting of three groups, of eighteen aircraft each, with the total varying from fifty-four to sixty aircraft. During the first few weeks of flying it, the following two variations were used. First, a lead group with one high wing-group and one low wing-group echeloned to the side. Secondly, a lead group with the high and low groups above and below, and slightly in trail. This second arrangement appeared somewhat like this in flight: 16
(see diagram)

The arrangement of the groups in this formation was effective in increasing the forward fire power and mutual support, but the formation was difficult to fly, particularly on turns. The high group had considerable trouble in keeping the lead group in view. Even with wing-men echeloned to the sides, this fifty-four aircraft formation proved unwieldy, and squadrons on the outside positions, both high and low, where only a few guns could be brought to bear, were clearly exposed to very heavy enemy fighter attack. Although the theory of the formation was excellent and the mutual support looked good on paper, the actual flying of the formation largely negated the advantages expected, so it was shortly thereafter replaced by a more compact Combat Wing of fifty-four aircraft.

X

As the war progressed in Europe the complexion of the air war changed somewhat, with variations of tactics and targets coming in some small measure almost daily. In June 1943 the first American fighter escort planes arrived in the form of P-47's of the Eighth Fighter Command. As the fighter force gained experience and equipment, the limit of their effective escort range grew from about one hundred and seventy-five miles to two hundred and fifty miles or thereabouts. But the range of the heavy bombers expanded with that of the fighters, and they continued to penetrate beyond the range of protecting escort planes. The really high priority targets in Germany came into the sweep of their operations, targets far beyond the two hundred and fifty mile radius of fighter escort, so mutual fire power support continued to be a most important factor in the bomber offensive. The Luftwaffe was still a very formidable force, and they soon learned to wait just beyond the range of our fighters, depending on the formations in great

numbers and with very great vigor when the escort turned back.

To continue to meet the growing need of mutual fire power two important variations of the fifty-four aircraft Combat Wing were used. First, aircraft in each element were stacked in one direction, while the elements and groups were stacked in the opposite direction. Secondly, the previously exposed highest and lowest squadrons were tucked in behind by reversing the echelon of the elements in each wing squadron of the group. This formation seems to have been the final word in uncovering fire power. The tucked-in formation afforded greater lateral compression, and increased considerably the number of guns uncovered, but it actually did little to solve one of the biggest problems of all, that of stragglers, responsible on some missions for over fifty percent of the losses. On turns the formations still spread, and there was an increase of use by the enemy of rockets into a large bomber formation to disrupt it, after which the enemy, with coordinated single-engine attacks, would pick off the stragglers. After such deep and costly penetrations as that of Schweinfurt and Stuttgart in 1943, all hope of sending formations deep into Germany against the fighter opposition the Germans were capable of putting up was abandoned, and the inflexible fifty-four aircraft Combat Wing was discarded.

With the flying of the fifty-four aircraft formation there were still other problems to be ironed out. One of these was the interval between Groups, while yet another was the problem of the climb in formation, and a third was the placing of Combat Wings in position in the task force. At the meeting of the Combat Wing and Group Commanders of 7 September, 1943, these problems were thrashed out in 1st Division Headquarters. On the problem of interval there was a certain amount

of uncertainty as to what interval was to be taken in flight. Colonel Putnam suggested a three minute interval, but Colonel Gross, commander of the 94th Combat Wing suggested that the leaders should be permitted to choose the interval as it suited them. The matter was dropped then, but taken up later at the meeting of the 29th of September when General Williams brought the matter up once again.

General Williams: How close can you fly Combat Wings in trail?
Colonel Lacey: I would say about one and a half minute interval, and it would be slightly echeloned then.
General Travis: I haven't flown in second position to tell.
Colonel Turner: I think five miles, for any length of time.
General Williams: Can you close up any tighter in near the I.P.?
Colonel Turner: Probably for about ten minutes, if slightly echeloned.

17

There was then, as there remained throughout this whole period, a certain amount of experimentation in each mission where the Combat Wings were flown in trail. Colonel Turner himself, on the occasion of the Combat Wing and Group Commanders meeting of the 6th of October expressed himself as being in favor of flying the combat wings at intervals of ten miles, double that he requested at the meeting of the 29th. Apparently the only solution was that given by Colonel Gross previously, to let the leader choose his own interval, depending on the amount of enemy opposition and on the presence or non-presence of contrails. Contrails meant just a greater interval had to be chosen, because they made tight flying just about impossible by blinding the ships following the leaders at a close interval.

As to the rate of climb of a Combat Wing, here, too, there was some

17 Combat Wing and Group Commanders Meeting, 29 September 1943:p.5.

divergence of opinion, varying with the time and position of the formation. The B-17 is capable of climbing at the rate of about five hundred feet a minute, but climbing at this speed under combat conditions, or even in formation without being under attack, was not possible. On the 30th of August 1943 on the mission to Romilly sur Seine the formations climbed at the rate of 300 feet per minute while going out over the Channel and into enemy territory, but it was not really a good test of the ability of the ships to climb in formation, as they were not under enemy fighter attack at the time. After the Schweinfurt mission it was generally agreed by the leaders that a climb of one hundred to one hundred and fifty feet per minute was plenty, and it was decided to use this rate as the standard. 18

Some special problems came up concerning the actual flying of the B-17 in addition to the ordinary method of getting the ships into formation and then out over enemy territory. Discussing the mission of the 15th of September General Gross (then Colonel) mentioned their special trouble. On the mission, planes of his formation carried special bomb racks to hold external bombs, increasing not only the weight of the plane, but also the drag in the air from wind resistance against the external bombs. On this mission, in his own words, they "crossed the enemy coast at one hundred and fifty-two miles per hour; in order to maintain that speed thirty six inches and two thousand two hundred and fifty revolutions per minute were required... I would recommend that with such a load as this, the mission be flown at not more than twenty thousand feet; that in planning future missions of this type, consideration be given to the fact that above fifteen thousand the lead airplane must pull too much manifold pressure to make two hundred feet per minute at one hundred and fifty miles per hour". 19

18 Combat Wing and Group Commanders Meeting, 7 September 1943, p.9.
19 Combat Wing and Group Commanders Meeting, 22 September 1943, pp.1&2

Fortunately the use of external bomb was dropped rather quickly, else the problem of flying any formation might have multiplied beyond count. General Travis remarked on carrying such a load that it was the opinion of an expert on the subject that the pistons in the motore suffered great strain, strain that would show up on the mission itself or in the missions immediately following, increasing the number of abortives greatly.

When missions were expected to be particularly tough, it was the policy to get them to altitude as soon as possible. On one occasion Colonel Gross remarked that his formation sometimes were cut down by abortives because of the constant~~ing~~ climbing before crossing the Channel, but General Williams said that as they could gain only three thousand feet crossing the Channel on their particular course, it was deemed wiser to have them climb to high altitude before reaching the Channel, so as to have them at a safe altitude for crossing the coast where the defenses might be strong. ²⁰ —

XI

Between mid-October 1943 and mid-January 1944, the Eighth Air Force experimented with a revised thirty-six aircraft group, and after this period the thirty-six aircraft group entirely replaced the unwieldy fifty-four aircraft Combat Wing formation. Two factors, more than any others, influenced the adoption of the thirty-six aircraft group as standard Operation Procedure, the introduction and extended use of overcast bombing, and the increasing range of fighter escort. About seventy-five percent of the Eighth Air Force's attacks in January and February 1944 involved German targets, with over half of these bombed

20 Combat Wing and Group Commanders Meeting, 6 October 1943, p.4.

through overcast. Because of the shortage of PFF equipment, it was necessary that squadrons be compressed as tightly as possible, and this was done by the twelve aircraft squadron, composed of four elements of three aircraft. All aircraft in an element flew at the same elevation. The four elements were: a lead, a high-wing, a low, and a low-low trailing. Three of these squadrons flew as a thirty-six aircraft Group. This uncovered more guns and increased cohesion of the individual unit, but the formation was still very difficult to fly. The groups flew behind each other at an interval of about four miles at the same altitude,.. 21 (see diagram)

21 Tactical Developments: pp. 26 & 28.

track each formation at their leisure, but could get accurate shots at only about one out of three. Generally the leader got it very heavily when the planes came in bunched closely.

II

To study the development of formation flying in the 1st Division, the first point to consider is the objectives of flying a number of ships in a planned formation. The original objective was to concentrate sufficient fire power to permit the formation to fly against any target in enemy territory in spite of enemy fighter attacks.⁶ The difference in viewpoint of the American bomber force from that of an other nation was its emphasis on security of force. The English Air Force, the RAF, flew by night to keep the Germans alert in that part of 24 hours-- for other reasons as well, of course-- and the American Air Force flew by daylight and kept the Germans alerted through their half of the day. To achieve any success in their bombing it was necessary to be able to fly today, tomorrow, and the day after, and to do this, the question of keeping the formations well protected, secure, was paramount. If we were not able to take care of ourselves in daylight operations, we would have to change to night flying, thus losing all the advantages of daylight bombing, the accuracy we hoped to achieve against targets that could actually be seen, and the constant pressure on the German anti-aircraft batteries, and more particularly on their front line fighter strength,. Every moment they were in the air over enemy territory the formations had to be prepared to encounter the Germans, had to be in good defensive formations.

⁶ Eighth Air Force Tactical Development, August 1942-- May 1945.
Prepared by Eighth Air Force and Army Air Force Evaluation Board,
E.T.O. p.2 (This work will be cited hereafter as Tactical Developments.

An interesting light on the concern the commanders had about security of force at all times can be seen in the Combat Wing and Group Commanders Meeting held at 1st Division on 7 September 1943. At this meeting one of the missions discussed was that of the 31st of August, 1943 to Romilly-sur-Seine. Colonel Gross, Combat Wing Commander of the 1st Combat Wing was asked his comments as leader of the mission for the day. The following conversation ensued.

Col. Gross. I have no comments whatever. As leader there was one point I thought we might thrash out. When I got to the I.P. and radioed back to the other Combat Wings that both the primary and secondaries were covered and to pick a target of opportunity, they immediately picked one and took off for home. I was some distance ahead of them and got left behind...

General Williams. Under fighter cover I think that's all right. If not under fighter cover I think you had better plan to attack a secondary or last resort and also plan a rally point...

Col. Turner. With the fighter opposition encountered of late, there is no sense trying to rally them. I'd suggest that we hit a target and get out.

General Travis. I would suggest that we let the situation make the decision for us. We gave the 4th Division a lot of help on this last raid by just coming in behind them and giving them position support, shooting down fighters trying to annoy them, etc. The fact that we were able to swing in behind them made it a defensive formation.

General Williams. A Combat wing should be able to take care of itself coming out. As a matter of general principle we will consider that the way to do it. If you are strung out through some special arrangement and not a closed formation, tell your people to work on another target and get out the best way you can." 2

It is interesting to note from this the concern felt by Colonel Gross over the fact that even in France, where opposition was not too great, he was separated from the rest of the Wing, thus weakening his defensive

2 Combat Wing and Group Commanders Meeting, 7 September 1943, p.1-2. (Minutes of these meetings are attached to the Mission Folder of 1st Division on missions preceeding the date of the meeting or may be found in the folder catalogued as #710-40 in the Baltimore Archives.)

formation. It is interesting to note General Travis's statement that just by flying behind the 4th Wing, later 3rd Division, they made a defensive formation that aided that Wing against fighter attacks. But most interest is the statement by General Williams that a Combat Wing should be able to take care of itself coming out. In general this proved true, but when the Germans went to work on a wing in earnest, it needed a lot of support to come back without being practically decimated.

Other factors were also involved in formation flying besides security of force. Some of these were: the size of the bomb pattern, the amount of visibility each member of the crew would have, particularly the pilot, the flexibility of the formation, the ease with which it could be flown, and the ability of the formation leader to command the formation once it was in the air.

The first of these, the size of the bomb pattern, was of very great importance. The whole purpose of sending planes out over enemy territory in any sort of formation whatsoever was to achieve as much bomb damage as possible to our target objective in Europe. To destroy a target it was necessary to send out enough bombers to carry the bomb load sufficient to saturate the target area in the portions that were known to be most vital, and it was necessary also to guarantee as much as possible that the weight of bombs dispatched would be placed on the target area in such a pattern as to cover that area most effectively. For each mission a point was chosen, called the M.P.I. (mean point of impact), in the target area, where the leader bombers were supposed to hit. If his bombs did hit there, and the formation was good, the pattern of the formation dropping on the leader would do the maximum amount of damage spreading from an important central point of

production in the target chosen. For bombing factories in Germany the quality of the formation was very important. If the bombs fell in the spot chosen as the M.P.I., you could be certain, barring freak hits, that the most important buildings of the whole factory would be either destroyed or put out of working order for sometime. The bombing of the Focke-Wulf assembly plant at Marienburg may be taken as the classic example of what could be done when formation flying was coupled with good placement of bombs. It was hit twice by the Eighth Air Force, once by the B-17's of the 3rd Division in the autumn of 1943, then six months later by the B-17's of the 1st Division in the spring of 1944. On each of these missions the amount of damage done was enormous. ⁸ On the first of these two attacks the plant was clearly put out of order for sometime by some of the finest bombing done to that date in the Eighth Air Force. Six months later the damage had been finally repaired and the production of Focke-Wulf fighters had recommenced, so a second attack was directed against this same plant. B-17's of the 1st Air Division flew against Marienburg on the second bombing, and the results were just as destructive as those of the first attack, with bombing rated even more accurate. This plant was not attacked again in the war. Either the Germans gave up in their attempts to rebuild it, or by the time they had the planes coming off their assembly lines we had made such inroads in their oil supply that the planes they produced were not able to fly because of lack of fuel. In each case the flak at the target was not what might be called prohibitive, giving the pilots

⁸ 3 AD Mission Folder for Mission of 9 October 1943.
1st AD Mission Folder for Mission of 9 April 1944.

plenty of time to get into good formation as they came in on the bombing run. And in each case the lead bombardiers hit their M.P.I., with the result that the plant was saturated by bombing. Both attacks might be called the ideal of achievement in bombing, combining an almost total saturation of the target with a minimum of losses in each case.

The remaining considerations in formation flying, visibility, flexibility, ease of flying, and ability to be commanded in the air, were all tied together. Every new formation had to be analysed carefully to study each of these points, to make sure that when the planes moved into the desired formation the result was not an unwieldy group of planes echeloned into position where they could not be sure of what was going on around them, with possibility of crash through sliding into a blind spot in the formation. The pilots had to be confident that the formation they were to fly was the best one possible to give them adequate protection: they could not fly a mission worrying about mid-air collisions as well as flak and enemy fighters. And if the formation were to be directed to its target, or to a secondary or target of opportunity, the air commander had to be placed in a position where he could easily command a view of, and direct the activities of the formation flying with him. Upon him rested the responsibility of the mission. Few criticisms were ever given about particular decisions made by air commanders, since they were put in their position only after they had proven their ability to think coolly in tight spots. But whether they were to be criticized or not, they had to make the right decisions everytime on the spur of the moment, for upon their ability to choose wisely depended uncounted human lives.

With such responsibilities resting on their shoulders it was inconceivable that they should have been forced to endure the added burden of an unwieldy formation.

III

On August 17th, 1942, the first formation of B-17's flew from England by daylight to open the American Heavy Bomber Offensive against Europe. The attack was carried out by two squadrons of B-17's of the 97th Bombardment Group. The lead ship of the squadron flew in the center with his wing man just to the right rear on the same level. Two planes flew high on the far left and right outside, while two planes flew low in the rear, tucked under the high outside planes. This was the squadron formation. ⁹ (see diagram)

⁹ Tactical Developments, pp 4&5

as the following groups had various other modifications in the nose mount of guns when they arrived in the theatre or did the modifications immediately after getting there.

In contrast to this B-17-E, the latest model of the plane, the B-17-G used at the end of the war, had the following armament: Two center nose guns mounted on a turret, Two side nose guns, Two upper turret guns, One radio room gun, Two ball turret guns, Two waist guns, and two tail guns, all guns being .50 calibre machine guns.

When in 1942 the Americans opened their part of the air Offensive against Germany, there were certain factors that had to be taken into consideration. First of all was the determination of the type of formation to be used. Bombing by single aircraft might be ideal for bombing accuracy, but it did not give anything like adequate fire-defense against enemy fighters. Bombing from very high altitude would reduce flak damage, but would cut down accuracy also. Flying large bombing units would give better defense against fighters, but increase the risk of flak damage. Heavy armament and gunners were good to protect the plane from enemy fighter attack, but the added weight cut down on manoeuverability, range, and bomb load. In flying a formation, too, it was difficult to choose a proper interval, one that would be both desirable from the standpoint of morale and one that would be effective, in the bombing. Too close an interval would result in crowding, with the danger of collision, principally on the bombing run, while too wide an interval would result in smoke obscuration for most of the bombing unit, and greatly increase exposure to flak fire. 3

3 Evaluation, page 4.

In working out the problems confronting them, the commanders of the Eighth Bomber Command came to the following Practices. The bombing was done at an altitude generally not less than 20,000 feet. On certain missions, such as the one to the Molybdenum Mines at Knaben, ⁴ Norway, this altitude was reduced because of special circumstances-- in the case mentioned, the defenses were expected to be so light that there was no apparent need to fly over fifteen thousand feet. But when, on normal targets in Europe, the formation came much below twenty thousand feet, the results were seen in the great battle damage sustained by the formation, generally in a quick jump in losses. In late 1943 an attempt was made to bomb the submarine pens at St. Nazaire from altitudes extending from 7500 to 12,000 feet, but the battle damage sustained by the planes in the lower echelons was so extensive that they did not attempt such low altitude bombing again. The choice of twenty-to twenty five thousand feet as the bombing altitude brought the ships up out of the deadly accurate range of flak guns, gave them something to work for if they were to hit our formations. Still it was not so high as to make accuracy in bombing impossible, or even very difficult if the bombardier was given a good chance to sight his target for a normal bombing run...

Bombing by single aircraft was not tried,, so far as this writer knows, by American bombers in the European Theatre of Operations. Sometime before the Americans arrived the British had two B-17-E's, which they sent out alone on a bombing mission to Brest. They had no .50 calibre guns on them, no tail gun position, of course, and were, in

⁴ A-3 Mission Report for 16 November 1943, Target Knaben, BDFO #236, 8AFF # 303.

general, ill prepared to meet opposition. While still some miles off the coast of the Breat peninsula, they sighted some Germans coming up to meet them, so, very wisely, they turned back. This abortive sortie was used by the oppo~~ent~~^{er} of heavy bombing to prove the fact that heavy bombing could not be carried out successfully by day. The opposition to heavy bombing died a slow but certain death. ⁵

American bombers flew in formation, from the very first mission on August 17, 1942 to the last one in 1945. That formation flying varied considerably over the years, but the formations were the peculiar trademark of the American Air Force in Britain. (The fact that we did fly by day, and did fly in formation, caused some hard feelings among the British occasionally. Particularlry was this so when the returning formations flew back over London. In the last months of the war the English people were given a really good air show when an entire mission, of well over one thousand bombers., flew low over London on their way back from an attack against Germany. The whole city came out to see the magnificent parade of heavy bombers, a parade that shook the whole city as though there were an earthquake. It was the most impressive air show this writer has ever seen, but it was possible to see in the faces of the people, and to gather from their talk, that though the sight of these magnificent formations could not help but impress them, they would still like to see the RAF able to steal our thunder and do a better job. Unfortunately the RAF were unpre~~pared~~^{pared} and unequipped to fly the formations we flew.)

⁵with Remarks above were gathered by the present writer in a conference with General Robert B. Williams in 1944. He discussed freely the development of the air war in Europe. Most of this material is to be found in the opening chapter of the History of the 1st Bombardment Division or Wing, cited above.

The carrying of gunners and of protective armor did add to the weight of the ship considerably, did reduce the bomb load, the range, and the manoeuverability, but this added weight was a necessary evil. If any attempt had been made to do away with gunners, there would have been no daylight bombing, probably no bombing at all. And the number of lives saved by protective armor was so notable that it was not economical to dispense with its use. Some rearranging of the armor plating on the plane was done at times during the progress of the war, but the weight of the overall armor was not notably changed. Added weight came when the gunners and other crew members were later equipped with flak suits and helmets as added protection against low velocity shells and flak,...

The problem of interval between various units in the formations took up most of the worrying in the development of bombing tactics. From missions there was a constant flow of complaints on crowding at the I.P., overrunning combat wings on the bomb run, ships being crowded out of formations by even the slightest change of speed in the lead plane, and often the wailing of the last man in the formation about the evasive action of the formation, where, if the speed ran up to about 160 miles an hour indicated air speed, a turn to the left followed by a turn to the right executed by the leader to confuse the ground crews tracking the formation acted like a whip when it got to the last plane, swinging it out in a long arc to the left, then a longer one to the right, leaving it sitting out alone at the end of the double turn. All through the war the varying amount of flak or fighters expected had an influence on the interval at which the formation flew. If flak was heavy it was generally better to run the Combat wings in quickly so the gunners on the ground would not have the opportunity to

The history of the development of Bomber formation flying in the 1st Division of the Eighth Air Force is, for all practical purposes, the history of the development of that type flying in the whole of the Eighth Air Force. It was this unit which, in the late months of 1942, started the heavy bomber offensive against occupied Europe, and much of the original work in formation flying had to be developed in this Division. In the last months of 1942 the Liberators of the Second Division--or Second Wing as it was then called-- joined the attack, and in the spring of 1943 the Third Division also joined.

In beginning this work of daylight bombardment, the Eighth Bomber Command was not entirely a pioneering outfit. In the earliest days of the war the Germans had embarked on a project to reduce England to a broken Country by bombardment, and in this they had used daylight bombardment as well as night attacks. As far as can be determined the Germans did not make a very thorough study of the problem to be confronted in daylight bombardment over England, as their formations were not such as to make defensive fire power notable, and the altitude at which they flew made them eminently vulnerable to British anti aircraft fire. They did see the necessity of fighter protection, sending their Messerschmitts along with the Ju 88's, Do 217's and 219's but the British fighter pilots were able to make the cost of bombing prohibitive by sedulously avoiding their fighter escort in anything like large scale dogfights, going after the bombers exclusively. So costly did this become that the Germans were forced to withdraw their daylight bomber force, sending them over at night when the attrition could normally be expected to be less severe.

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The three type ships used by the Germans in their daylight blitz against England could not be called heavy bombers. They were the Heinkle-111, the Junkers-88 and the Dornier 217. They were all twin engine aircraft, with a bomb load somewhere between one and two tons, not very heavily armored, and not flown by men prepared to fly the very scientific formations later flown by the Eighth Bomber Command and Eighth Air Force heavy Bombers. The altitudes from which they attacked varied, but did not generally run over 15,000 feet, and flak at that altitude can be very accurate indeed. The formations flown by these German pilots was, at best very ragged, and there seemed to be no planning to it. Sometimes a formation of ten bombers came in together, sometimes sixty. They apparently had no set rules about who was to fly where, but merely tacked onto one another as they choose, with the wiser pilots getting into large formations and the young fresh pilots coming in just about alone in great glory. The glory boys were buried in south England, and the old soldiers got back to Germany with their formations. While all this was going on, the American Air Force was observing.

Though we were not in the war in those early years, there were still men in England who were able to observe these interesting facts about the formations flown and record their observations. One of these men was Lt. Col., later Major General, Robert B. Williams, in England as an American observer. From the crews of the Hurricanes and Spits who had attacked the Germans he got their reactions to formations, and very soon the word passed back to the United States that what the pilots didn't like was bigger and better formations, so the development of formation flying went on with this in view all the time. 1

1. History of 1st Bombardment Wing from beginning to August 17, 1942. (the matter in this part is largely gathered from a conference of the present writer and General Robert B. Williams. (Histories of Division will be cited so, with month given~~XI~~))

The original heavy bombers in the European Theatre of Operations were the B-17's of the 97th Bombardment Group(H), the group which flew the first heavy bombardment mission against occupied Europe on August 17, 1942. These were B-17-E's. The first B-17's to fly in this war were the ones in the Pacific Theatre, B-17-D's with no tail turret. They proved so vulnerable to tail attacks that the plane was redesigned and a tail position added to protect against attacks from the rear. The B-17-E was an improvement on the D model, but certainly was not the Fortress that came out of the war as the B-17-G.

The original B-17-E had the following armament:²One center nose gun, Two upper turret guns, Two ball turret guns, Two waist guns, Two tail guns. All guns on the plane, with the exception of the nose gun, were .50 calibre machine guns, capable of firing about six hundred and fifty rounds per minute. Two sets of twin fifties were mounted in turrets, the upper turret just behind the flight deck, and the lower turret, or ball turret, mounted below the ship just behind the radio compartment. This latter ball turret had a very great range of fire, enabling it to cover any attack from an angle below the ship. The waist guns were mounted on either side of the waist, and the tail guns were mounted on a flexible mount as twin guns. The nose guns in the first B-17's was a thirty calibre machine gun originally hand held, with a ring and post sight, movable, firing through any of four eyelets in the plexiglass nose. Later the gun position was modified to put the same in a ball and socket mount so as to fire through one eyelet in the center of the nose-- this was true of the ninety-seventh Group only,

² An Evaluation of Defensive Measures Taken to Protect Heavy Bombers from Loss and Damage: Hq Air Force, Operational Analysis Section: page 83. (This work is cited hereafter as "Evaluation").