

# **FORMATION FLYING**

**U.S. NAVY**



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**U.S. NAVY PRIMARY FLIGHT TRAINING MANUAL**

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## FORMATION

In FORMATION flight, you begin the first application of your flying technique to modern military tactics. Formation flying is just as much a military flight operation, as your gunnery and bombing runs, which are just ahead of you. In reality, formation flight is **more** important because it is the basic **foundation** of all successful bombing and gunnery runs.

Heretofore you have necessarily been learning to fly and to think only in terms of **yourself** and **your own** individual airplane. Now, in formation, you and your airplane become merely a single part of an operating unit which includes some of your fellow pilots and their airplanes. However, this operating unit of several pilots and airplanes must perform as a **single** airplane to achieve its purpose. This is the thought which you must believe and strive to execute in order to become a Naval aviator. It is enough to say that your formation work may be compared to the smart squad on the drill field which marches, counter-marches and responds in unison to orders, though many individuals comprise the unit and determine its movements. Think also, by way of comparison, what the chances of success are for the football team, whose every member is not **where** he should be **when** he should be there.

In your primary formation training you are not expected to become a polished formation pilot, with complete knowledge of every detail on the subject. However, in order that you learn the fundamentals involved and generally familiarize yourself with formation procedure, we must start somewhere, and this is that place.

Here are the things which you should get from your primary or introductory formation training:

1. Realization that successful formation flying depends upon cooperation, teamwork and consideration of all pilots.
2. Control of your individual airplane should be secondary so that you can apply yourself to the solution of other problems. You will learn to use the controls automatically to keep your airplane and its attitude in the desired relationship to the rest of the formation - just as you subconsciously slide through automobile traffic without mentally referring to brake, accelerator or wheel.
3. Ability to anticipate and think ahead of your airplane, so as to control it as desired **before** corrections become necessary.
4. Ability to fly your airplane in a steady and constant position in relation to the rest of the formation.
5. Proper use and interpretation of signals between members of formation.
6. An understanding of your responsibility to other members of formation.
7. Knowledge and purpose of unbalanced use of controls.
8. Basic formation organization and units. (The three plane vee and echelon).
9. How to assemble and break up a formation.

## SIGNALS:

The signals and signaling procedure described below are standard for Navy formation and no variations will be permitted. These signals and their execution will be followed throughout your primary formation training, so that you will learn the complete procedure. Remember, every change in the attitudes or control settings of the leading plane requires one or more signals from the leader to the wingmen. It should be realized, however, that in the more advanced phases of formation flying, very few signals will be necessary to maintain the perfect teamwork of your section.

1. Maneuver: Vee section take-off.  
Signal: Leader holds left fist upraised.  
Receipt: Both wing-men repeat same signal.  
Execution: Leader lowers upraised left fist to apply throttle for immediate take-off.
2. Maneuver: Climb.  
Signal: Leader points upward with thumb or forefinger and motions forward with head to indicate the addition of throttle.  
Receipt: None required or affirmative nod of head.  
Execution: Leader adds climbing throttle, while motioning head forward.
3. Maneuver: Turn.  
Signal: Leader makes sweeping action with thumb or forefinger in direction of turn.  
Receipt: None required, or affirmative nod of head.  
Execution: Leader starts to establish turn smoothly and deliberately after giving signal.
4. Maneuver: Level off.  
Signal: Leader runs fingers or palm of hand horizontally back and forth across the top of the windshield.  
Receipt: None required, or affirmative nod of head.  
Execution: Leader proceeds to level off deliberately after giving signal and motions head forward or aft as he adds or retards throttle.
5. Maneuver: Straighten out.  
Signal: Leader places hand held vertically in for and aft attitude against windshield.  
Receipt: None required, or affirmative nod of head.  
Execution: Leader proceeds to roll out of turn deliberately, after giving signal.
6. Maneuver: Power glide.  
Signal: Leader points down with thumb or forefinger.  
Receipt: None required, or affirmative nod of head.  
Execution: Leader noses down smoothly and motions head backward while retarding throttle as desired.
7. Maneuver: Slower speed.

- Signal: Leader motions head backward and retards throttle deliberately, as desired.
8. Maneuver: Increase speed.  
Signal: Leader motions head forward and adds throttle slowly, as desired.
9. Maneuver: Join up.  
Signal: Leader makes series of shallow climbs and dives with smooth fore and aft movement on stick and then starts wide turn, which enables other airplanes to join him by cutting inside his turn.
10. Maneuver: Touch and go landing.  
Signal: Leader moves palm of hand downward and forward, followed by upward and forward motion. (**Note:** This is one continuous motion but consists of two signals; the first part indicates landing, and the second part indicates take-off) The signal is given by placing the hand outside the cockpit and is repeated on both sides using left and right hand, for the benefit of each wing-man.  
Receipt: Affirmative nod from wing-men.  
Execution: Approach is begun when in position and appropriate signals follow as necessary attitude changes are required.
11. Maneuver: Final landing.  
Signal: As in touch and go signal the hand is placed over the side and palm is moved downward and forward (landing), then the fist is clinched and held down and forward, indicating application of brakes (stop - no take off). This is repeated on both sides.  
Receipt: Affirmative nod of head from both wing-men.  
Execution: Proceed when in position to start approach.
12. Maneuver: Break up from Vee.  
Signal: Leader pats head and points to wing-man desired as new leader, then points in the direction in which he will turn after break-up.  
Receipt: Designated wing-man pats head to indicate acceptance of lead.  
Execution: Leader rotates stick as signal of execution and enters shallow dive straight ahead until 200-300 feet below formation, then turns 90° in indicated direction.
13. Maneuver: Break-up from echelon.  
Signal: Leader pats head and points finger to nearest wing-man. (**Note:** Leader always rolls **away** from formation when leaving echelon and should plan to proceed in that same direction.)  
Receipt: Wing-man pats head indicating acceptance of lead.
- Execution: Leader rotates stick and rolls away from echelon.
14. Maneuver: Cross-over from vee to echelon.  
Signal: Leader raises right arm (for right echelon) with clenched fist and holds above right side of cockpit. (**Note:** for left echelon - left arm is raised and held above left side of cockpit.)  
Receipt: Both wing-men repeat same signal, (same arm), and hold until leader observes them.  
Execution: Leader lowers signal arm and moves ailerons with small but rapid side motion of stick - not enough to rock wings. Designated wing-man then moves to new position.
15. Maneuver: Return from echelon to vee.  
Signal: Leader moves elevator slightly with rapid series of short fore and aft movements on stick. (**Note:** if these control signals are given rapidly enough they should not and will not effect the attitude of the airplane.)  
Receipt: First wing-man immediately repeats signal for benefit of next wing-man.  
Execution: Last wing-man starts crossback immediately to vee position. (**Note:** When in echelon, wing-men will promptly relay all signals from the leader for the benefit of the last man, whose vision of the leader may be obscured. This relay signal procedure is followed regardless of number of airplanes in echelon.)
16. Maneuver: Change of lead in echelon.  
Signal: Leader pats head and points finger toward nearest wingman who is to be next leader.  
Receipt: New leader pats head, indicating acceptance of lead.  
Execution: Leader rotates stick and then assumes new position to form vee on new leader.
17. Maneuver: If you fail to recognize or interpret a signal.  
Signal: Shake head negatively. This means "I do not understand, please repeat".
18. Maneuver: If you wish to cancel or nullify your own signal or another's signal.  
Signal: Wave back of your hand or hands in front of your face as though erasing. This means "negative, belay"—followed by the correct signal.

The execution of these signals is an art in itself. It requires a high degree of finesse and should not be passed off lightly. It will be beneficial to you and the members of your formation to practice these signals together on the ground. They should all be given in a very obvious manner and repeated, or held long enough, to assure complete recognition and interpretation by your wing-men. Get your hand up high enough to be seen

above your cockpit. Repeat signals on both sides if required. When necessary to give signal on one side only, do not allow your arm to be pulled out of position as you turn your body to look back at wing-man for his recognition. Always over-do the giving of your signals, rather than under-do it.

Care must be taken, when giving signals and turning your body or head to receive recognition, that you do not inadvertently apply control pressures and change the attitude of your airplane just as your wing-man may be preparing to release his controls in order to signal his recognition.

Whenever practicable, two or more signals may be given at the same time or consecutively, to enable more than one element of attitude or control setting to be altered simultaneously.

Signals are very exacting, but are just as flexible as your imagination, initiative, and ability to fly. Obviously it is permissible to roll from a turn directly into a turn in the opposite direction, after so signaling. It is not necessary to first signal for and return to straight flight, before starting a turn in the opposite direction. Attention is called to this feature as you will encounter it when leading in turns and clearing turns in formation flying.

Remember, that after you have signaled for and established a turn, dive or climb at a constant rate, **that** attitude is **it**. Any time thereafter that you wish to steepen it or shallow it out, you must give additional signals to indicate a change.

#### RESPONSIBILITIES OF THE LEADER:

It can never be over-emphasized that the lead position is the most important in the formation and the most responsible position to which any pilot flying in formation can be assigned. This lead position is also the most difficult to fly correctly, and you should guard against the tendency to relax when taking over the lead, after having concentrated on holding a wing position for some time.

Poor formations, are often the result of faulty leadership. The fact that wing-men are out of position does not necessarily indicate faulty technique on their part, but may indicate that the leader lacked **consideration** for them and flew away from them. Remember you are not only flying your own airplane **for them**, but in reality you are "flying" the whole formation as one big "airplane", the extremities of which you "fly" by "remote control". For this reason, you must plan further ahead for all your problems of flight, whether they be direct or indirect, and fly smoothly and accurately at all times.

Formations can, within reason, execute almost any maneuver of which a single airplane is capable. However, since the formation is less flexible than a single airplane, (due to unavoidable reaction time), all changes in attitude and control settings should be executed by the leader smoothly and **DELIBERATELY**. This is the key work of good leadership and the more extreme the attitude change the more **DELIBERATELY** and smoothly you should lead into and recover from it.

To be a good formation leader, you must always remember that these are your responsibilities:

1. Always keep your wingmen in mind and know where they are at all times. Now and then, actually look directly at the other pilots, instead of just viewing their airplanes out of the corners of your eyes. They may be trying to signal

some information to you.

2. Analyze what is to be done, far enough in advance, to prevent sudden changes in altitude, attitude and speed.
3. Act as the "eyes" of your wingmen at all times. Remember, they have their vision fixed upon you and your airplane.
4. Give all signals to your wingmen obviously and unmistakably in a **DELIBERATE** fashion and do not execute them, until ample time has elapsed for their recognition.
5. Confine your signals to those standard procedures which apply to the maneuver or message you wish to execute or convey.
6. Do the navigating for the formation and make sure you are in a familiar area, headed for familiar landmarks, before passing the lead. On their first formation flight, your wingmen, in concentrating on their positions on you, may fail to note the formations course and position in the area.
7. "S" turning, clearing the flight area and generally observing other aircraft and traffic are entirely your duty.
8. Observe all traffic rules and regulations. The leader is responsible for all **infractions** of course rules and flight regulations.
9. Make certain that the entire formation is able to clear all obstructions on take-off and landing.
10. Lead formation from line and establish proper position, heading and course for take-off. Do the "looking aft" and "looking forward", for all concerned.
11. Coach your wingmen and foster teamwork in your section.
12. Observe weather conditions, any recall signals, etc., and take proper action for the safety of your formation.

#### When you are a wingman, these will be your responsibilities:

1. Maintain proper and constant position in relation to leader.
2. Maintain exact and constant position, while other members of the formation are changing their relative positions (crossovers, etc.)
3. Maintain proper pattern of changing positions as you cross over, change lead, etc.
4. Make the leader's job as easy as possible by attentiveness. He has many responsibilities. You cannot shoulder these responsibilities, but you **can** lighten his burden and gain the approval of your fellow pilots.
5. Be alert for your leader's signals at all times.
6. Acknowledge leader's signals promptly, when required, but be positive of their meaning.
7. Execute the leader's signals as you would any military order.

#### FORMATION TAKE-OFF:

Your formation will be designated as a three plane section on the schedule board. The first airplane listed will be the leader of the formation. The second airplane listed will be the number two airplane and the third one will be number three airplane. The number two position is on the leader's left and

the number three position is on the leader's right in a vee section. The phrase "vee section" means just that. The three airplanes appear to form a letter V when viewed from above or below. The leader is at the apex of the vee and the wingmen are at each extremity.

All three airplanes should prepare to leave the line at the same time and proceed to taxi out normally, with the leader in advance. As the three airplanes approach the take-off position, the leader will taxi far enough onto the mat or field, to allow his wingmen to take their positions, clear of the taxi strip and clear of taxi traffic. Severe traffic congestion results when formation airplanes foul the taxi strip during their take-off preparations, and solo airplanes are forced to wait before they can taxi to their take-off positions.

When the leader has established his position, the wingmen will proceed to take their position in relation to him as follows: they will be abaft the leader on approximately a 30° bearing from his longitudinal axis. (Determine this by sighting from your cockpit to the corresponding cockpit in the lead airplane). The wingmen will be outboard of the leader, at a lateral distance sufficient to provide a safe clearance of approximately ten feet between wing tips, in the event that they should overrun the lead airplane. The airplanes will now be in correct position for simultaneous, three plane formation take-off.

The leader's engine will be at idling R.P.M. prior to starting take-off. The wingmen's engines will be turned up to approximately 1000 R.P.M. while holding position by application of brakes. The purpose of this advanced R.P.M. is to enable the wingmen to start moving smoothly as the leader begins to move and, consequently, varies with the type of runway surface. A soft dirt or grass field requires more preliminary power than a smooth, hard surface.

After the leader has ascertained that all is clear for take-off and wingmen have indicated their readiness, he will lower his left hand, (which has been raised), toward his throttle as a signal of execution and shall begin opening the throttle slowly, but continuously to the desired power setting. The leader must use great care not to advance throttle too rapidly, which invariably results in leaving the wingmen behind. If you do observe wingmen dropping back, do not continue adding throttle but hold its present setting. **NEVER CLOSE THROTTLE OR RETARD IT EXCESSIVELY ON TAKE-OFF**, as wingmen will overrun you.

When the wingmen see the lead airplane begin to move, they will immediately release their brakes and maintain their position on the leader, with whatever throttle application is necessary. They will, however, change from their **ground position** in relation to the leader, to the **flight position** on the leader as soon as they can safely attain flying speed. This is done at once when you feel your airplane reach a speed sufficient for flight. At this point, add considerably more power to enable you to gain enough altitude to place you higher than the leader, for your flight or step-up position, which will be described later.

The leader will hold his airplane on the ground by prolonging his take-off run until the wing airplanes have taken this step-up or flight position in relation to him. As the wingmen establish this new position, the leader will immediately allow his

airplane to become airborne, but should do so with very deliberate addition of throttle and change of attitude. The climb may be started then, as soon as a safe speed has been reached.

On the take-off run, it is imperative that the leader continuously ascertain the positions of his wingmen and slightly vary his throttle application, if necessary, to aid their efforts. As leader, you should take particular pains to maintain a straight track on the take-off run and climb, so as not to swerve in front of a wingman. Also strive for a constant rate of acceleration, with no prolonged run just below flying speed, when controls have not reached their full effectiveness.

When you take-off in a wing position, remember that the leader is constantly accelerating and that if you delay in starting with him or drop back, it will be difficult to catch up. On the other hand, should you tend to overrun the leader, you can drop back into position easily by slightly retarding the throttle, or by holding it in its present position momentarily, during your process of gradually opening it.

Great care should be taken to avoid veering into the turbulent area behind the leader's airplane. In the event that you ever get into this turbulent area on the ground, close the throttle and keep your airplane on the ground. If your airplane is already airborne apply full power and turn outboard of the formation. In this case quick and sometimes full application of the controls will be necessary.

Your base or station field will be used for formation take-off at the beginning of the flight, but NOT for practice landings and take-offs thereafter, unless specifically authorized. At the end of the flight, your formation will break up in the air and proceed to the base field singly.

#### FORMATION CLIMB:

Following the take-off, and as the leader observes his wingmen to be in the proper step-up position, he should establish a safe flying speed and then immediately start the climb. This is done by slowly and deliberately putting his airplane into a normal climb attitude after giving the appropriate signals. The wingmen will have ample time to vary their attitude and add necessary climbing throttle, if the leader is smooth and deliberate with his signals and execution.

The number one pilot should lead his formation climb at an airspeed slightly above normal solo climbing speed. For N2S formation this speed will be 65-70 knots. This, of course, is merely an increased safety factor, which provides a more positive control, should any of the formation experience turbulent air or other cause for quick and full control movements.

You will climb straight out of the field after take-off and start a turn only after reaching the proper altitude and complying with other traffic regulations. Always be careful not to lead your formation into a tight place in traffic or into the turbulent area behind other airplanes climbing out. As you climb out into the practice area, remember to lead your formation through a continuous series of gentle deliberate clearing turns, for the purpose of clearing the area ahead, which is partly obscured by the nose of the airplane.

The altitude for formation practice is always above 1500 feet and below 2000 feet, actual altitude above the ground. By

observing this regulation your formation will be high enough to fly safely over outlying fields and pylon areas, and yet be below the acrobatic area, which is above 2000 feet. As you are climbing to 1500 feet for your practice, follow all traffic rules and channels, as specified for your station and be careful not to lead your section over outlying fields, pylons or other congested areas. Even after reaching your operating altitude of 1500 to 2000 feet above the ground, avoid flying over these areas of concentrated traffic in so far as possible.

**All formation practice will take place between 1500 and 2000 feet, except the climb-out and the let-down for approach and landing in formation.**

#### STRAIGHT AND LEVEL:

After the wingmen become airborne on take-off, their position in relation to the leader for climbs and for straight and level flight is as follows:

The wingmen will be above, behind and out at an angle of approximately 45° from the leader. The lateral or horizontal separation should be such that your wing tips would safely clear the leader's wings, should you overrun him. The step-up or vertical spacing above the lead airplane should be such that your landing gear would safely clear his top wing and rudder should you overrun him. This step-up is usually designated as approximately 15 feet, although it is much easier to determine a **safe and proper** step-up than is a "15 foot" step-up.

The number two pilot is usually considered second in command of the formation; consequently the number three pilot should dress his airplane laterally on number two. This assures a symmetrical formation, but also places more responsibility on the number two pilot for holding a proper and constant position on the leader.

Each of the three directional elements that make up your position are basically controlled by one of your three fundamental controls, (stick, rudder, throttle). To move fore or aft in adjusting your bearing on the leader your throttle is the control to be used in **conjunction with necessary attitude changes**. To move into or away from the leader, (left or right) rudder is used to actually skid the airplane while opposite aileron pressure is used if necessary to prevent the airplane from banking and turning. **Your wings should always be level with or parallel to the leader's wings.** To increase or decrease your vertical position or step-up on the leader, the stick is the control to be used in conjunction with the throttle as necessary. However, you should not be impressed with the importance of any particular control. Rather you should learn to maintain a broad field of vision in which your airplane is related to that of the leader, and your controls should be coordinated in relation to changing attitudes of your airplane as well as in anticipation of signals for turns, climbs, let-down, etc.

Anticipation of **when** to use each control and **how much** of each to use is very important and is directly related to their reaction times. You will notice that the **nose** responds almost instantly by lowering when **forward pressure is applied** to the stick. But when the **throttle** setting is increased or decreased the airplane does **not** react for a very appreciable

length of time. Hence, anticipating the use of throttle is even more important than anticipating use of stick and rudder.

The throttle is of great importance in formation work. At first most students start pumping the throttle back and forth erratically — mainly because they are uncertain of what they are trying to do and because they fail to realize that some time is necessary for the airplane's power to change the airplane's position. A little reasoning will assure the wingman that the leader's throttle is being held in a fixed position. Therefore, the wingman should try to find the corresponding position for his own throttle, and then make only minor adjustments for corrections in position. Make small adjustments in throttle at once and give the airplane longer to react and correct its position. This will prevent over correcting and use of a wide range of throttle, in an attempt to find its proper setting.

The elevators are used with the throttle to maintain vertical position, or step-up. In all formation work, the pilot should guard against over-controlling and make corrections as gently as possible. The tab can be used to relieve pressure on the stick.

The rudder is used with the throttle to maintain lateral position. Gentle pressure on the rudder pedals will develop a slight skid for gradual changes in lateral position. Bear in mind that skidding will slow your speed by the introduction of more drag, so that it may have to be accompanied by a slight increase of the throttle with required altitude changes.

The ailerons are used for the **sole purpose of keeping the wings parallel with those of the lead airplane. Use the leader's wings as your horizon, and keep your wings parallel with his. When he banks, you bank with him.**

#### TURNS:

In turns the whole formation banks like a single airplane. Visualize both this and your position as only one part of the complete formation and you will have no trouble. The secret of executing a smooth turn consists of having the wings of all the airplanes in the formation parallel, just as in straight and level flight. This means that the leader must fly a smooth, balanced turn and that the wing-men use the leader's wings as their horizon.

A turn to either side may be made in a vee formation. The leader must enter the turn slowly, increasing the bank gradually until the desired angle of bank is reached.

In level flight there is a 15-foot step-up between the horizontal geometrical plane containing the wings of the section leader and that containing the wings of the wingmen. In making turns this step-up is gradually reduced until in a theoretical 90° banked turn the same vertical plane should contain the wings of all three airplanes in the section. For any turn less than the 90° banked turn, the amount of step-up, above the plane containing the section leader's wings, should be proportional to the angle of bank. Thus if you have a 15-foot step-up in level flight, about an 11-foot step-up in a 30° bank, in a 45° bank it should be about a 7½ foot step-up. These heights are used merely as an example to help you visualize the variation in amount of step-up as angle of bank changes. The "step-up" refers, of course, to the geometrical plane containing the

leader's wings. As the bank increases in a turn, the outside man decreases his step-up but **increases** (with respect to the earth) his height above the leader, and increases his throttle. The inside man also decreases his step-up but drops **below** the leader's height above the earth and **decreases** his throttle.

The leader must remember to control his air speed smoothly in turns to make it easier for his wingmen to hold their relative positions. An airplane on the inside of a turn will have a shorter radius and distance to travel than the other airplanes, therefore, if the leader in a vee section should allow his airspeed to approach the stall point, the inside man will be even slower with the probably obvious results. The difference in airspeed between the leader and the wingmen in some turns will vary as much as 5 knots.

The airplane on the outside of a turn has farther to go and hence must have slightly greater airspeed. In echelon turns, away from the echelon, the leader should reduce his speed sufficiently to enable the outside airplanes to keep up.

#### POWER GLIDE:

In formation flying altitude is dissipated in a power glide. You will readily understand that if the leader should close his throttle completely for a glide, his wingmen would not necessarily maintain the same speed and position merely by closing their throttle too. Slight variations in gliding characteristics of the three airplanes would result in different speeds for a given attitude.

For this fundamental reason the leader leads the formation in its descent by only partially closing his throttle. The amount that you close your throttle, when leading, will depend upon the rate of descent you desire. When leading formation, you will never close it entirely, (except upon contacting the ground in landing), but will always maintain sufficient power output to provide your wingmen with an ample range of throttle settings to maintain their position on you with safety.

As mentioned above, the rate at which you wish to dissipate your altitude is established by your power output or throttle setting. Airspeed in the power glide should be in the range just below cruising speed. This is not to be confused with the formation approach for landing which approximates slow flight procedure.

Your position as wingman in a power let-down is approximately the same as that used in level flight with this one exception. Your step-up will be slightly less. The amount by which you decrease your step-up depends directly upon how steeply the nose is lowered below the level position. The reason for this one variation in position is to give you better visibility of the lead airplane, so adjust your step-up accordingly. The greater your rate of descent the less your step-up. In some let-downs, therefore, you may be on the same plane as the leader's airplane with no step-up on him.

#### VEE TO ECHELON:

A crossover designates the maneuver executed, by the number two or number three wingman in a three-plane vee formation, in forming an echelon of the three airplanes. The maneuver may be executed by the wingman crossing **over** the

other wingman or by crossing **behind** or **under** him. Depending upon the type of airplane or operation, one or another of the three procedures will be used. In primary formation you will use a method that combines the cross-over and cross-behind methods. However, for purposes of convenience, hereinafter we shall refer to the subject maneuver as the **crossover**.

Crossovers from vee formation to echelon will never be executed except in straight and level cruising flight, between 1500 and 2000 feet above the ground. As leader you should ascertain that your wingmen are in good steady position and that you are satisfactorily clear ahead, to eliminate any possibility of encountering dangerous traffic or cloud conditions, before commencing the maneuver.

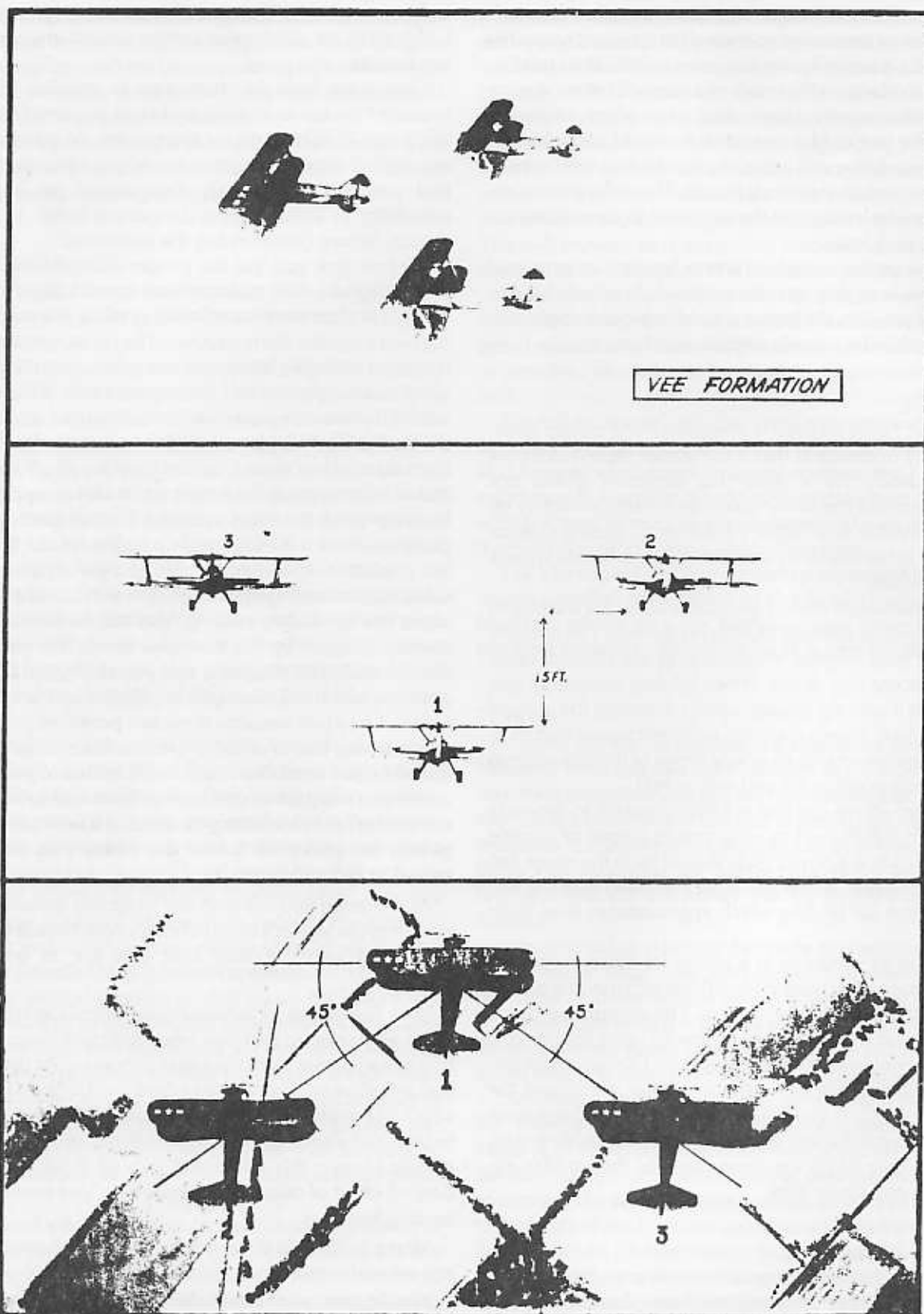
Be sure that you get the proper recognition signals from your wingmen, then maintain very smooth flight at a constant altitude and on a constant heading, while the wingman crossing over executes the maneuver. The crossover consists of one wingman changing his normal vee position on the leader to the same relative position on the opposite side of the other wingman. The result is an echelon formed behind, aside and above the leader. Each airplane establishes the standard position on the next airplane ahead, so that they are all on the same 45° line of bearing abaft the leader, each with an approximate 15 foot step-up on the airplane ahead. In other words the third airplane will have a 30-foot step-up on the leader. If yours is the last airplane you should be able to sight all the pilots in the same line, indicating a good echelon with all concerned on the same line of relative bearing. You will be familiar with your starting position by the time you reach this stage, but you should study the diagrams and visualize your **final** desired position, which will place you in echelon on the other two airplanes. Once you visualize these two positions, you will be well on your way, but, in order to execute the change from one to the other, you must also visualize the **series of positions** through which you will pass as you change from one to the other. It is not enough to see **where you are** and **know where you are going**, but you must **know the route you are going to travel** in order to get there.

As wingman you will start the crossover immediately upon receiving the leader's signal of execution. He will not give you this signal until he sees that you are in good starting position.

Your first step is to increase your altitude in relation to the other airplanes, so that you have sufficient clearance should you actually pass over the other wingman. At the same time you will allow your airplane to drop back slightly to a position which will enable you to clear the other wingman as you pass behind and above him. You will find that as you raise the nose slightly to gain this additional step-up it will also have the desired effect of causing the airplane to lose some distance or to drop back.

After establishing this position level off and avoid the loss of any more distance and hold this increased step-up.

Your next step is to start a slow, deliberate skid in the desired direction, being very careful to keep your wings level, even if opposite aileron is necessary to do so. This skid will, of course,



cause the airplane to slow down and lose distance, unless additional power is added in proportion to the rate of skid. This skid is the key note of a good crossover and like all other formation work, should be **slow, well planned** and **DELIBERATE**.

A very common error, made in crossing over, is to lose distance or drop behind the other airplanes. When you notice this tendency, add considerably more throttle, lower the nose slightly and release some of the rudder pressure, if you are still skidding. This will enable you to catch up to your proper position, while continuing to move over laterally. This will not happen, however, if you anticipate proper addition of the throttle at the outset.

You will at first get the impression that you skid your airplane continuously from start to finish position. In reality this is not what takes place in a good crossover. Instead you skid the airplane to a new heading and then fly it in a perfectly normal balanced flight condition on this heading which will take you to the new position. Upon arriving there you again skid your airplane back to the original heading and continue to fly in the direction the whole formation is moving. When you skid all the way across the constant rudder pressure causes an excessive change in the heading of your nose in the direction of skid by the time you reach your destination and as a result it is difficult to get the airplane back on the desired course with the other airplanes. This introduces the common error of skidding out too far and banking back toward the formation in an attempt to stop your lateral movement and resume the formation's direction of flight.

**Think about this.** Skid your airplane as necessary but remember very little **is** necessary. Keep it in balanced flight whenever possible, but do not bank the wings when changing your relative position in the formation. Later, in heavily wing loaded operational aircraft, you will discover that if the wings are allowed to bank in a crossover, the resulting slip is very difficult to stop with precision, causing a tendency on the part of other pilots in your formation to become apprehensive.

Upon reaching the opposite side of the formation and stopping your lateral movement you will be in a position just aft and slightly above what would be the standard position on the other wingman. It remains, therefore, merely to descend slightly to your approximate 15 foot step-up position on him while coming forward to your 45° angle of bearing abaft both the wingman and the leader. You will visualize these positions better when you realize that you have a 15 foot step-up on the wingman ahead of you, but a 30 foot step-up on the leader.

Here again you will notice that, as you lower your nose slightly to decrease step-up, you will also gain some forward distance in relation to the other airplanes so that very little throttle adjustment will be necessary at this point. Considerable throttle change may be necessary, however, as you skid into and out of your change, in heading for the crossover and you should not hesitate to use it smoothly as necessary. Learn to anticipate its use, rather than waiting for errors to demand it.

Since you change from one side of the formation to the other in a crossover, you will have to change your line of vision from one side of your airplane to the other, somewhere

enroute, in order to keep the other airplanes in sight. You should start out by observing the other airplanes normally and keep them in view as long as possible. When they pass from sight below and in front of your airplane, quickly change your sight to the other side, while maintaining constant control pressures to keep your airplane moving over continuously. You may have to overcome a normal tendency to "pull-up" slightly during the crossover. This causes more trouble, as the increased distance reduces the perspective of the other airplanes and they may become lost under your wing. Should this ever occur, do not pull up—do not drop down, but **continue to skid in the original direction** until visibility is re-established. Never close the throttle in this situation in an attempt to drop behind the other airplanes, because the result will be to drop down instead.

You can hold any position you want in relation to the other airplanes, so think of the crossover as a **series of positions**. If you skid too fast, you'll skid too far—take it easy! Thirty to forty-five seconds is normal time for the execution of a vee to echelon maneuver.

During a crossover, the non-active wingman is responsible for holding a very exact and constant position on the leader, in order that the wingman executing the crossover will have a steady guide on which to base his positions. He will not drop down or pull forward out of position in an effort to make the crossover easier for the other wingman. After the echelon has been formed, this middle airplane must continue to hold its position correctly and constantly, as the position of the airplane behind in echelon is based upon this middle airplane's position.

The second airplane in echelon will be responsible for passing on all signals to the third airplane in echelon.

#### ECHELON TO VEE:

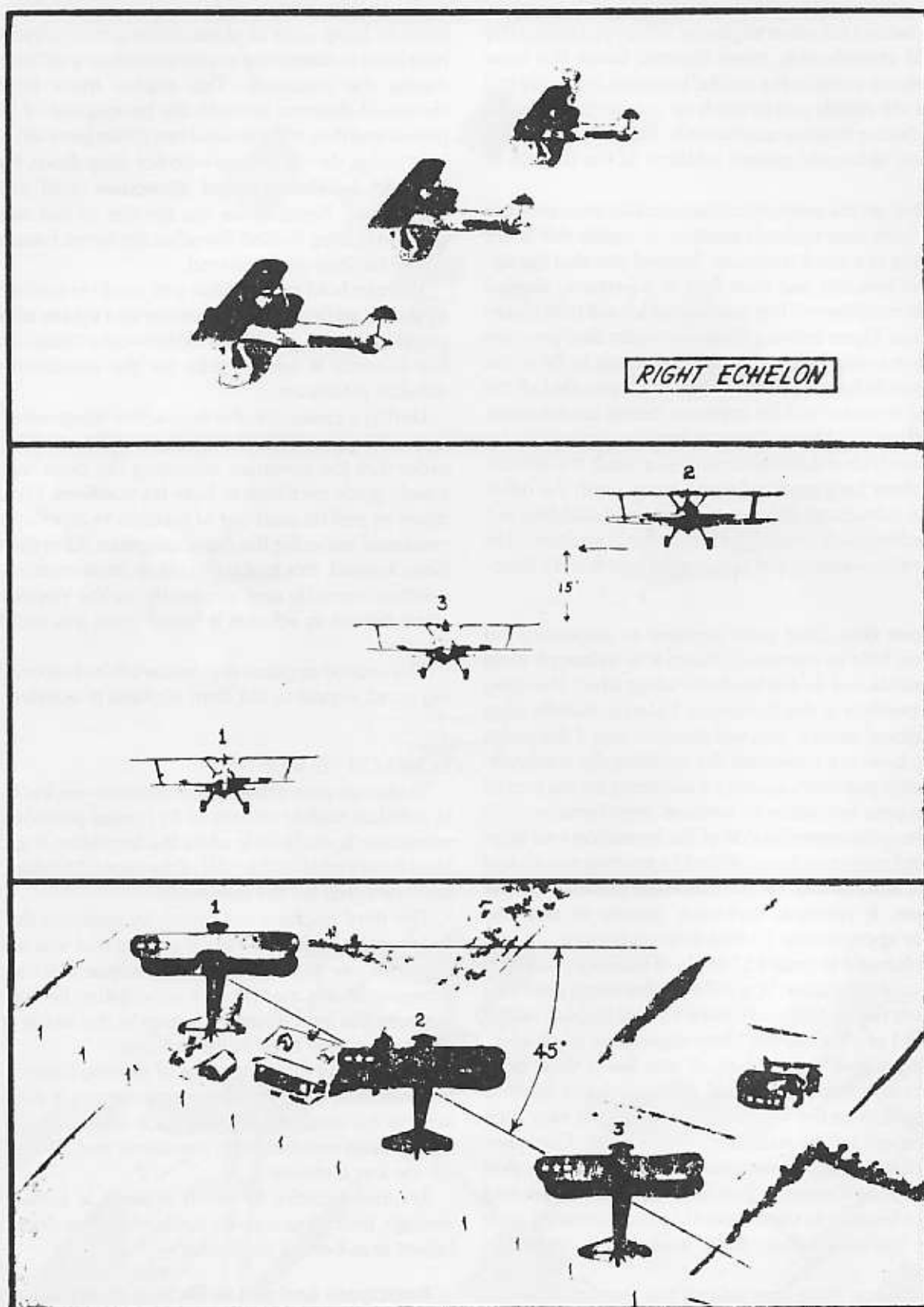
To change your echelon formation to vee, the third airplane in echelon merely returns to its former position in vee. This maneuver is made only while the formation is in straight and level flight and after the pilot of the second airplane repeats the leader's signal for the maneuver.

The third airplane will return by applying the same principles and following the same pattern that was used in changing from vee to echelon. As the airplane is moving across, however, in this maneuver it should also be flown **forward**, because the final desired position in the vee is ahead of the starting position back in the echelon.

By following this procedure of moving forward while moving over, one of the most common errors is eliminated. This error is the tendency to **drop** back while moving over, which results in an unsatisfactory maneuver and difficulty in making up the lost distance.

Another mistake to guard against, is failure to skid far enough, thus allowing your airplane to drop down into the turbulent area behind the leader.

**Anticipate and use sufficient power to maintain the desired position at all times. Keep your wings level. Be smooth, deliberate, and plan ahead.**



## EDITOR'S NOTE

Many of the biplane pilots today prefer to use the CROSS-UNDER method of changing position in formation rather than the CROSS-OVER method as described in the U.S. Navy Manual. The techniques are exactly the same except that the airplane moves underneath the other airplanes in the formation rather than above them. The CROSS-UNDER method has the advantage of providing the pilot with much better visibility and a lesser chance of losing view of the other airplanes while making the change in position.

### CHANGE OF LEAD:

In order that all pilots in the formation may have practice in leading during each period, a standard method of changing the lead has been developed. This method enables you to change the lead from either left or right echelon, depending upon which wingman you wish to designate as the next leader.

Before executing the change of lead, the leader will first ascertain that all is clear ahead and that he is operating in the 1500-2000 foot altitude zone above the ground. He then signals the change of lead to the nearest wingman (#2 in left echelon and #3 in right echelon). When the wingman is ready, he will give the acceptance signal accordingly and will maintain constant altitude, heading and throttle setting, while the leader moves into his new vee position on him.

As leader, you will do this by gradually skidding away from the new leader and, if necessary, reducing throttle slightly to retard forward motion and permit you to drop back slowly. While changing your position after passing the lead, you will keep the new lead airplane in sight constantly throughout the maneuver. In order to do this, it will be necessary to stay slightly below or in your step-down position until you have dropped back abeam or slightly abaft the new leader. You then gain your step-up, using throttle as necessary to assume your wing position on the new leader. After the change of lead, the section will be in vee formation and each airplane assumes a new number, corresponding to its position in the vee.

Until you have been introduced to the crossover and resulting echelon formation, you will not change the lead in the air. Instead you will break up your vee formation, land singly and reassemble on the ground in new positions.

### BREAK UP FROM VEE:

After you learn the echelon, all break-ups will be from echelon and always between 1500 and 2000 feet. However, until you reach this stage of your formation training, you will break-up from the vee formation as described below.

When the wingman, you have designated as the new leader, accepts the lead by acknowledging your signal, you will indicate by pointing, the direction you intend to go, and then give the signal of execution. You can turn either to the left or to the right, after leaving the vee, but you should plan your break-up so that you turn in the direction of the airplane which you

designated as the leader before leaving. This facilitates his break away from the last airplane and is a small part of what is meant by planning. Immediately after this, you will nose over smoothly in a normal dive until you are 200-300 feet below the remaining formation. At this point start a medium diving turn for 90° in the direction you have indicated, (left or right.) Never dive abruptly or steeply out of formation. Always watch for traffic below you and level off before going below the altitude prescribed by your local course rules.

After the original leader leaves by diving down and out of the formation, the wingman **not** specified as the leader will take his normal position on the new leader by skidding over, dropping back, and stepping up.

The new leader will fly straight and level upon the departure of the original leader for about ten seconds. He then repeats the leader's signals and departs. You will note that the two airplanes that remain after the first departs form an echelon. It is not necessary, therefore, for the second leader to dive straight ahead to clear the remaining airplane. Instead, he will use the regular echelon break up procedure, which consists of rolling away from the other airplane or airplanes and starting a dive at the same time, until he has turned approximately 90° from the formation's heading.

As each pilot successively becomes the leader, he will keep the airplane of the previous leader in sight so that, as he also leaves, approximately ten seconds later, he, like the others, will have the relative positions of all airplanes in mind. This also facilitates the forming of an extended column for landing and reassembling on the ground.

### BREAK UP FROM ECHELON:

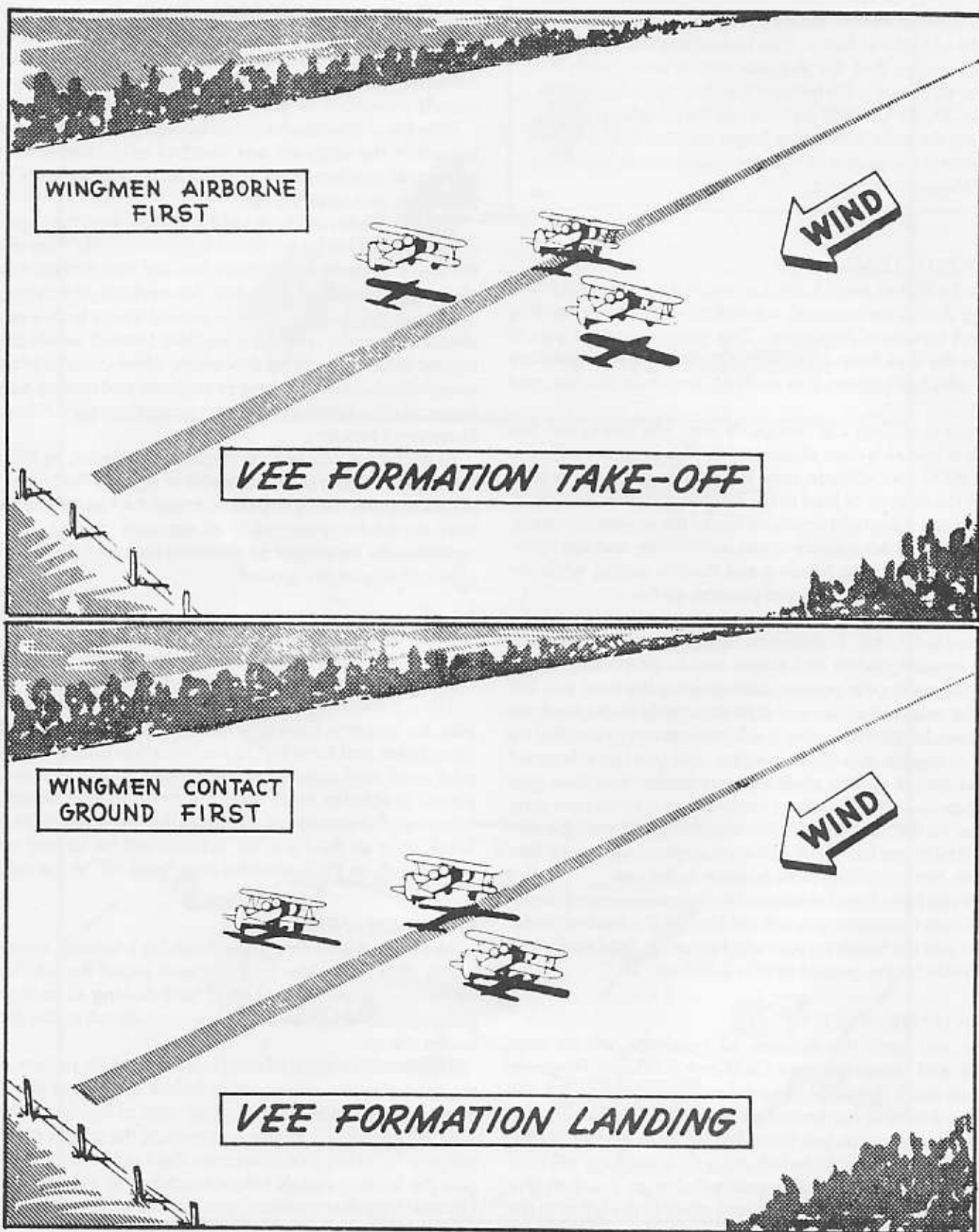
When you have learned the echelon, all break-ups will be made from that formation rather than from the vee.

The signals for passing the lead successively from the pilot to pilot are the same. Each pilot rolls and dives mildly **away** from the echelon and turns 90° to the formation's path. Since each pilot must turn away from the formation, the airplanes are placed in echelon away from the contemplated direction of break-up. For example if the desired direction of flight **after** break up is to the right, the echelon will be formed on the leader's left, so that each pilot may "peel off" to the right.

### APPROACH AND LANDING:

As you lead your formation down for a landing, utilize the power glide procedure until you have joined the field traffic. Remember your responsibilities for following all traffic rules and regulations, and for observing other aircraft on the ground and in the air.

You should be squared away in the field traffic pattern, at the required altitude, considerably before arriving at the 180° down wind position abeam to the point of intended landing. This will enable you to give and execute the proper signals to get your formation into slow cruise flight at 65-70 knots and to give the landing signals before reaching the abeam position. On reaching that position, you immediately begin a 180° power approach at 60 knots, using the proper signals to cover each change in attitude or control setting.



This power approach to the landing line is no wider or more extended than the pattern made by a solo airplane, making an approach with the same speed and power.

The success of a formation landing depends chiefly on leadership. The approach has to be made entirely with power, because, (as mentioned before), if the leader closes his throttle, the wingmen may over-run him. In order to control the airspeed, rate of turn and rate of descent in such a way that the formation may be landed at the desired point, the leader must use very fine judgment and plan far ahead. Without this planning and head work, drastic corrections will be necessary and although you might succeed in making them while solo, the inflexible nature of the formation makes a correct approach imperative, if a good and safe landing is to result.

The wingmen in this approach take a position on the leader, which differs from the normal position only in that the step-up may be reduced as necessary, to provide the best visibility of the leader, as in practicing power glides at higher altitudes.

As the leader joins the landing line and squares away on his final heading for the landing, he will give the straighten out signal and the wingmen will drop down slightly below the leader, **in a definite step down position**. This step down enables the wingmen to contact the ground just before the leader. The wingmen will also open out from the leader slightly, as they did for the take-off run, in order to clear the leader's wing tips, should they over-run him.

As the formation squares away on the final straight-away for the landing, the airspeed is reduced to approximately 55 knots, by entering the slow flight attitude.

The formation landing is always a power landing. This means that the leader always has some power on so that the wingmen can reduce their throttle settings further, should they tend to over-run him.

The leader must remember that his wingmen are in the step down position and must lead them so as to clear all obstacles safely.

A good leader will keep his head turning so as to observe both wingmen out of the corners of his eyes, for the purpose of

making small throttle corrections, should they over-run him, and to enable him to use sufficient power to prevent his landing, until the other airplanes have actually contacted the ground.

After the entire section is on the ground, the leader will maintain a straight track, without swerving to right or left. When the take-off, (touch and go), is desired, the leader will make a forward sweeping motion with his **left** hand to signal that he is ready to start opening his throttle, as soon as he lowers his hand.

Should the leader encounter drift on the final approach, he will make the proper correction by lowering a wing, but maintaining the desired straight path over the ground, (slip method), and the wingmen will do likewise.

As a wingman in the formation landing, you will do well to realize that the leader is continually closing his throttle and slowing down in the final approach. Therefore, be careful not to over-run him, as it will be difficult to drop back, since your throttle is almost closed already. On the other hand, should you drop back a little too far, it will be easy to catch up since you have a wide range of power over the leader.

#### CONCLUSION:

Formation flying is not a series of **corrections** made to keep your position, it is a series of **plans** derived from knowledge, headwork and alertness, which are executed to avoid the necessity for corrections.

**Anticipation of errors** is the most important technique which the primary formation student must learn. It is not enough that you learn the fundamentals as outlined above, for the results could still be rough. In order to make the formation smooth and efficient, you must recognize conditions which **could** throw you out of position and make your plans before the actual error develops.

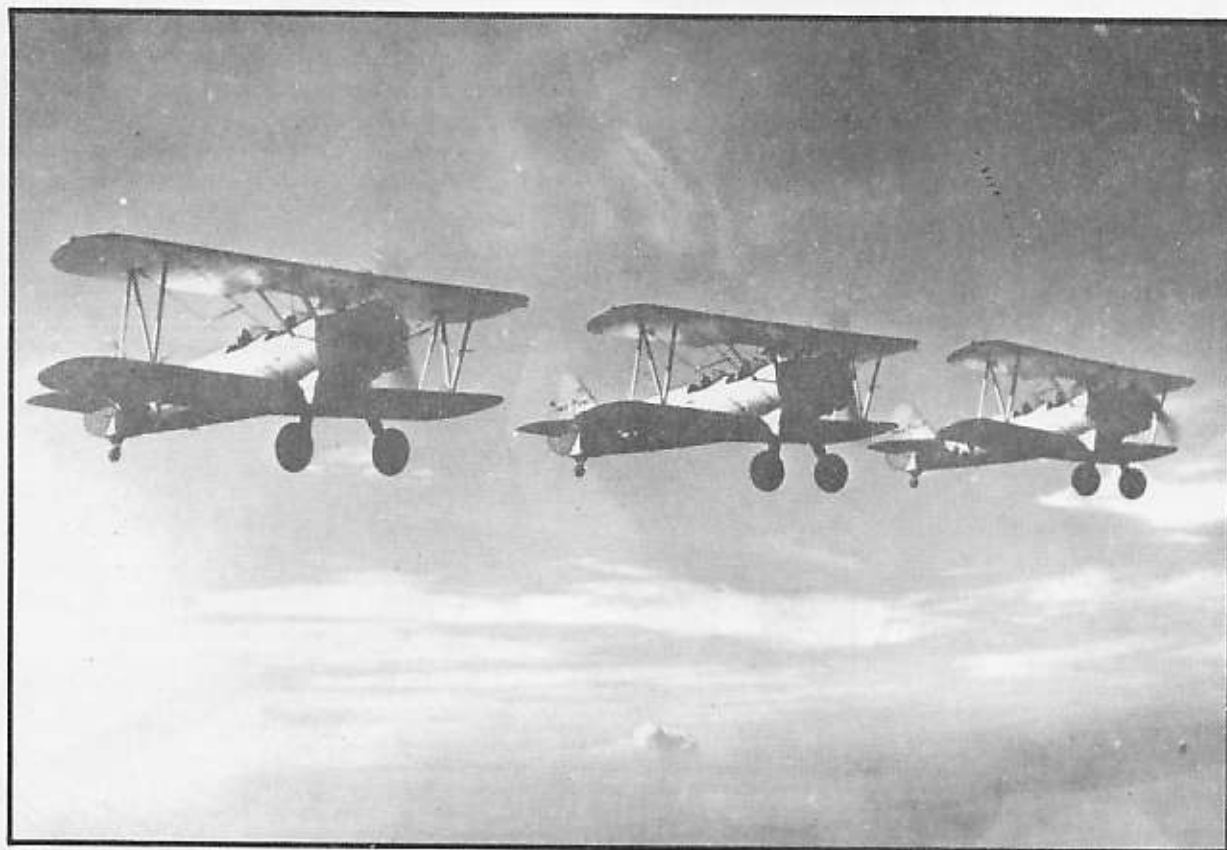
It is the spirit of mutual confidence and cooperation that makes possible good formations and great air power. You are now ready to achieve this goal, by continuing to develop your confidence, cooperation, headwork and planning.





*Wright J-5 powered  
Stearman NS-1 trainers  
fly in an Echelon Right  
formation.*

Photo: U.S. Navy via K. D.  
Wilson Collection.



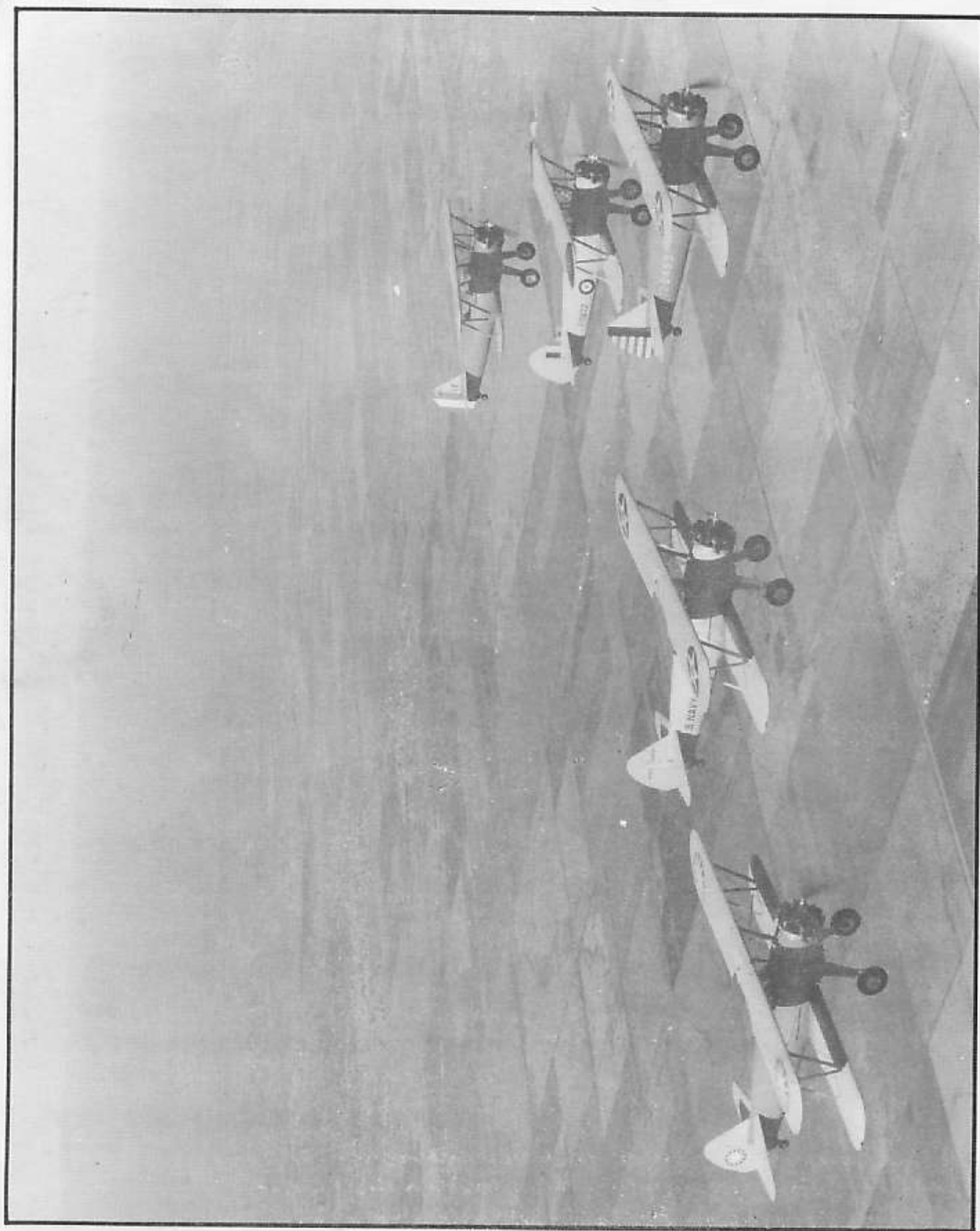
*Navy N2S-3s perform formation flight in Line Abreast during WW II.*

Photo: U.S. Navy via K. D. Wilson Collection.



*U.S. Navy N2S-3 trainers fly over the control tower at NAS Ottumwa, Iowa on 27 June, 1943. Note that there are instrument training bands painted on the wings but not on the fuselage.*

*Photo: U.S. Navy via K. D. Wilson Collection.*



Shown in flight over Wichita, Kansas in 1942 are from L to R: a Chinese PT-17; Navy N2S-3; Army PT-17; Canadian PT-17; and a Peruvian PT-17.

Photo: Stearman Aircraft Co. via K. D. Wilson Collection.