The AOPA Instrument Nav/Com Course

A uniform system of study for the nonprofessional pilot who wishes to become more proficient and to fly more safely. It is a course in basic instrument techniques and procedures under the direction of a qualified flight instructor.

The AOPA Instrument Nav/Com Course is a continuation of instrument training designed to follow the AOPA 360° Rating Course and provide Federal Aviation Agency "Blue Seal" licensed pilots with an introduction to the skills and knowledge required for instrument rating. This course consists of four hours of ground school and four hours of flight instruction.

A Safety Project of the AOPA Foundation, Inc.

● This manual was developed for pilots who desire to increase their knowledge and skill in flying and to gain an insight in the use of navigational aids, the communications system, and basic procedures required in training for an instrument rating.

The AOPA Instrument Nav/Com Course manual is a textbook for students to use under the guidance of an instructor giving the AOPA Instrument Nav/Com Course in accordance with the syllabus furnished him by the AOPA Foundation, Inc. Its usefulness however does not stop here. Information on navigational aids, communications systems and basic maneuvers are of interest to every VFR pilot. The manual was prepared by The Ohio State University, School of Aviation and the school's Chief Flight Instructor, G. Courtney Chapman (AOPA 155905), under a contract with the AOPA Foundation, Inc. A companion piece available for flight instructors has also been prepared by the Ohio State University for the Foundation. It is a syllabus for flight instructors to use in giving this course. The AOPA Instrument Nav/Com Course and the necessary training aids, including the printing of this manual, were made possible by the voluntary donations of AOPA members to the safety work of the AOPA Foundation, Inc., which also fostered the AOPA 180° Rating, the AOPA 360° Rating and other vital safety projects.

A word of caution—do not try to teach yourself these procedures from this manual or other textbooks. The guidance of a competent instructor is needed.

For information on how instructors may obtain copies of the AOPA Nav/Com Course syllabus, turn to back cover.

In the Instrument Nav/Com Course, the Blue Seal-rated pilot will build on the knowledge gained in the 360° Rating Course and progress in the sequence of training maneuvers required for an instrument rating. After a brief review of the AOPA 360° Rating Course, the pilot will practice control of the aircraft using a no-gyro instrument panel. The FAA navigation and communications network will be discussed and the pilot will then be introduced to a series of radio-navigation procedures used when flying under Instrument Flight Rules.

SECTION ONE

Basic Instrument Control

The control of aircraft attitude solely by reference to instruments was accomplished in the AOPA 360° Rating Course. The 360° course stressed "attitude instrument flying," that is, control of aircraft attitude when the natural horizon is replaced with an artificial horizon.

In the pilot training manual for the 360° course, the function and characteristics of each flight instrument are discussed. For the required maneuvers, each instrument is interpreted step by step to describe how they relate to aircraft performance.

The flight procedures are based on using the gyro horizon as the *master instrument* for attitude control. The gyro-horizon allows for precise control of the aircraft through a picture of an artificial aircraft and an artificial horizon. The gyro-horizon is designed to give precise measurements of nose and wing position. All other instruments serve only to support the master gyro-horizon.

The next step in your training is to develop and increase the degree of skill in interpretation of the support instruments by using them as the sole reference to control the aircraft. This method of aircraft control is often referred to as "no-gyro panel flying." It is a method that must be used in aircraft that are not equipped with the gyro-horizon, or in the event outside mounted venturi ice renders the gyro-horizon unusable, or in the rare case of a gyro-horizon malfunction.

In control of the aircraft through a no-gyro panel, nose and wing position are determined from the support instruments. These instruments do not relate directly to the horizon. Where we could previously measure the aircraft's attitude directly and precisely with the gyro-horizon (that is, measure nose and wing position with respect to the horizon), we cannot with the supporting instruments.

To determine aircraft performance through a no-gyro panel requires a process of gathering information from two or more instruments. It also means that a higher degree of skill is needed to interpret instruments since none of the support instruments are designed to provide the pilot with direct pitch or bank measurements. Each of the support instruments provides pitch and bank information *only indirectly*.

As learned previously, confidence and understanding are gained through study of the characteristics and functions of each instrument. A study of the following instruments will greatly assist in interpretation of each instrument and its relationship to control of the aircraft. (These descriptions are an expansion of the basic material in the AOPA 360° Pilot Training Manual.)

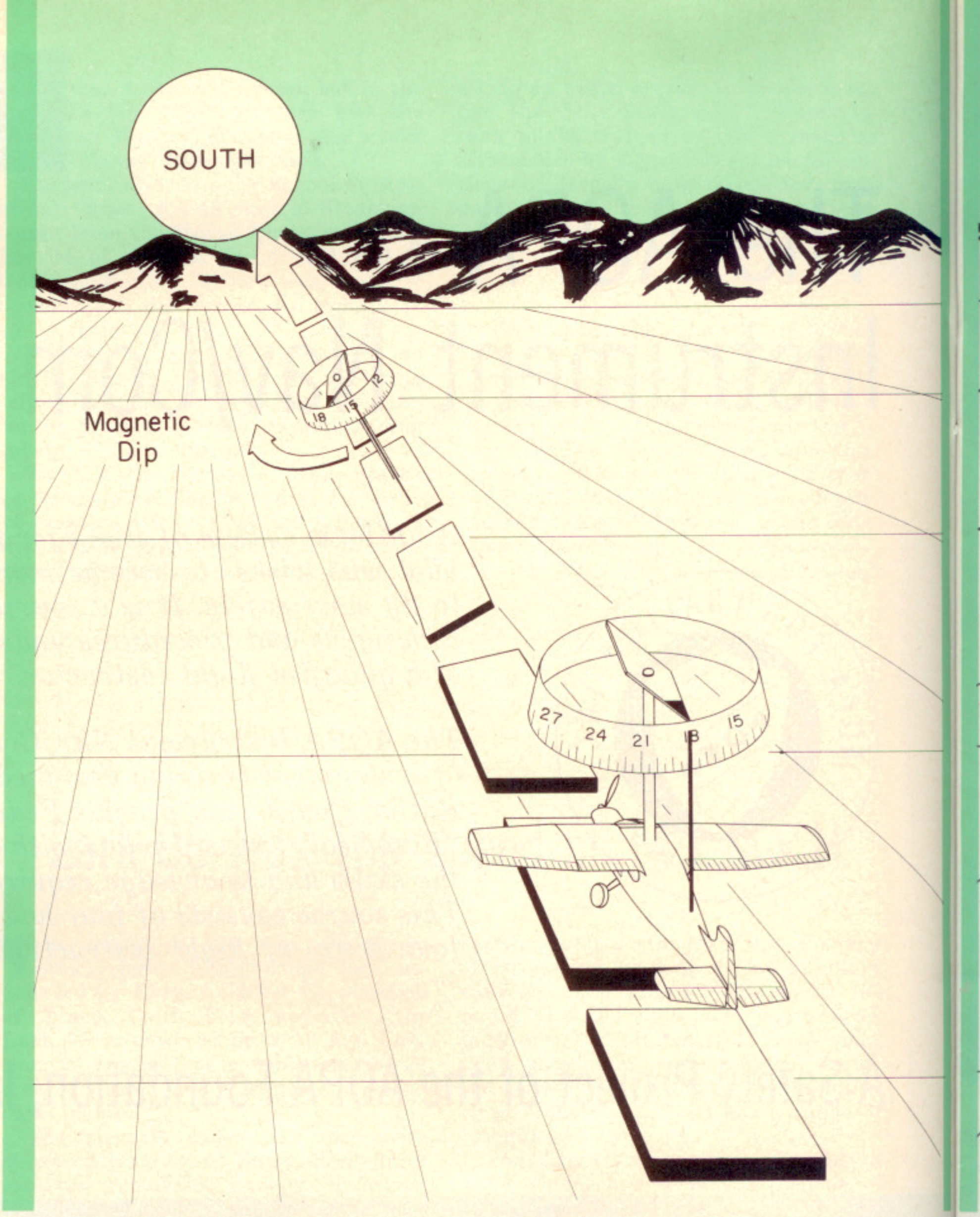
RATE OF TURN INDICATOR

In flying with a no-gyro panel, the turn needle is the primary indicator for determining wing position. *In coordinated* flight, it points in the direction of the low wing and indicates the rate at which the aircraft is turning. It does not, however, directly indicate angle of bank. The angle of bank can be determined since it is a function of both airspeed and rate of turn (shown in the table in Diagram 13).

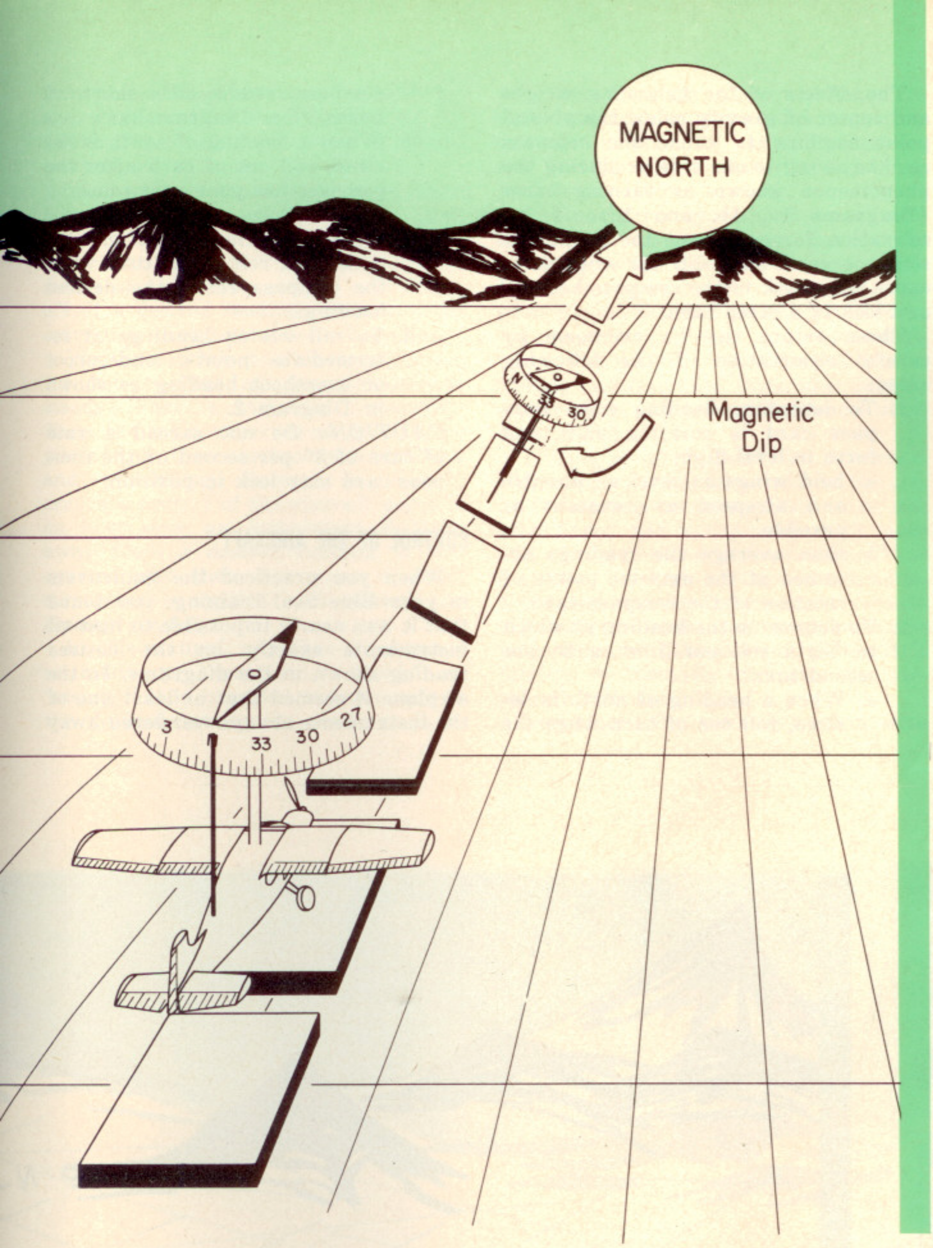
However, in no-gyro panel flying, since determining angle of bank would continually require an extra mental calculation, reference to angle of bank will not be made. All wing positions will be with reference to the rate of turn, which can be read directly.

An important characteristic of the rate of turn indicator is that the needle will swing "nervously" and oscillate from side to side in turbulent air or from rough control usage. This is because of its sensitivity. The sensitive swinging creates certain difficulties in interpreting the needle. To determine the existing rate of turn, it is necessary to obtain an average of the needle movements (See Diagram 3).

The average is the point halfway between the short duration needle movements—to the left and to the right. The *average* point, regardless of how far



DIAGRAMS 1A and 1B (1B is at right) Magnetic compass errors caused by turning and accelerations



the needle swings, will provide an accurate indication of the rate of turn. However, since a certain amount of time is necessary to average the needle oscillations, your effective control of wing position will be less precise than with the instantaneous measurements available on the gyro-horizon.

In practice maneuvers, the rates of turn normally referred to are:

1. Zero rate—wings level
2. Standard rate turn—3° of turn per second, indicated by the doghouse (See Diagram 3A)
3. One-third standard rate—1° of turn per second (used for small adjustments in directional control)

Control of the wing position (rate of turn needle) is accomplished through coordinated use of ailerons and rudders. The ball indicator reflects skids and slips (uncoordinated use of controls). If the ball is out of the center, an easy rule to remember is "step on the ball" and apply just enough pressure to bring the ball into the center.

THE AIRSPEED INDICATOR

In no-gyro panel flying, the airspeed indicator is the primary indicator of the aircraft's nose position. For the discussion that follows, it is important to remember that elevators control the nose position and that all adjustments to the airspeed will be made with the elevator control.

In wings level flight (zero rate of turn) the airspeed indicator is interpreted as follows:

If *constant airspeed* is held, a constant nose position is being held.

If *airspeed is decreasing*, the elevator has been moved upwards and the nose position is rising.

If *airspeed is increasing*, the elevator has been moved downward and the nose position is lowering.

Since the airspeed indicator, by itself, cannot provide a measurement of nose position with respect to the horizon, the above interpretations are valid with either high or low airspeeds. (Actual nose position with respect to the horizon is a function of power and airspeed.)

Entering a turn has the same effect as a downward motion on the elevators because of the centrifugal force created when the aircraft is turning. It is necessary, then, to move the elevators upward each time a turn is entered to keep the nose from lowering. The amount of upward elevator movement will depend on how large is the rate of turn. But once a constant rate of turn is established, nose position indications are interpreted as described above.

As proficiency increases, you will become aware of the rate at which the airspeed indicator changes. This will, in turn, tell you how fast the nose position is changing. From this rate of change, you will begin to develop a "feel" for how much elevator pressure is necessary for airspeed (elevator) adjustments. But even this "feel" will not tell you where the nose is with respect to the horizon. The over-all performance of the aircraft is determined from a combination of rate of turn and heading instruments and the power setting.

THE ALTIMETER

The altimeter provides the pilot with the primary indication of power setting.

As you recall from previous flying experience, it was found that for any given airspeed there is only one power setting that will give you level flight. If you desired to change altitude with constant airspeed, your elevator position remained constant but power was adjusted. If you desired to change airspeed, elevator position was changed and power had to be changed only to maintain altitude. The power-altitude relationship was stressed by your instructor during practice of slow flight and especially during final approach where maintaining a constant airspeed was essential.

Thus, in level flight the altimeter is interpreted as follows:

If the altimeter is decreasing and the airspeed is as desired, power is low and should be increased.

If the altimeter is increasing and the airspeed is as desired, power is high and should be decreased.

If the altimeter is steady but higher or lower than desired and the airspeed is steady on the desired setting, power must be decreased or increased, respectively, to return to the desired altitude. Upon reaching the desired altitude power would be returned to the original setting.

If the airspeed and altimeter are both off the desired readings, adjust elevators to obtain the desired airspeed, then adjust power to obtain the proper altimeter setting using the rules above.

In climbs and glides, power determines the rate of altitude change. The elevator is used to obtain the desired climb or descent airspeed.

Also in turns, when the airspeed has been adjusted to compensate for the centrifugal force created by turning, the altimeter-power, airspeed-elevator relationship remains the same as described above.

VERTICAL SPEED INDICATOR

The standard vertical speed indicator has a built-in lag characteristic that delays needle indication by as much as nine seconds. This delay makes the indicator unreliable for nose position indications. It is useful for obtaining rates of altitude change only after steady airspeed and power settings have been maintained for approximately nine seconds.

If installed in the aircraft, the newer instantaneous vertical speed indicator, which provides an immediate response to changes in rate of climb, is much more reliable and useful. The new instantaneous vertical speed indicators can be used for nose position indications in the same way as the airspeed indicator.

MAGNETIC COMPASS

The magnetic compass is another instrument that has an indicator that rotates. It swings from heading to heading and at first glance would appear to be unreliable. But it, too, like the rate of turn needle, can be used effectively if a few simple rules are followed.

The swinging compass card and certain other errors in compass readings are caused by features in the construction of magnetic compass indicator. These errors are referred to as deviation, northerly turning error, and swinging.

The magnetic compass is designed with adjustable compensator magnets which vary small magnetic fields in an attempt to cancel out other magnetic fields caused by electrical equipment and metal in the aircraft. However, all the magnetic disturbances around the aircraft cannot be cancelled out completely. After adjusting the compensator magnets, any error between compass card reading and the true magnetic direction is listed as deviation on the *deviation card.* This card is placed near the compass. Be certain yours is up to date.

The compass card rotation and the phenomenon of northerly turning error are the result of two factors: (1) the earth's magnetic field, whose lines are not parallel to the earth's surface (they angle down toward the poles); and (2) mounting the compass card magnets on a pivot, and with the center of gravity of the magnets below the pivotal point.

To correct for the tendency of the north-seeking side of the compass card magnet to line up with the earth's magnetic field (pointing slightly downward), a small weight is placed on the south side of the magnet. The compass card is in a delicate balance. When acceleration forces are placed on the aircraft from turbulence, turning, or changing airspeeds, the delicate balance around the pivotal point is disturbed.

The effects of the balancing weight and center of gravity below the pivotal point combine to cause the compass card to swing to one side producing the phenomenon known as turning error (Diagrams 1a, 1b, and 1c). If acceleration forces become too great, the compass card may dip far enough to cause it to stick to the compass housing and lock in a steep turn.

These errors can be overcome by careful observation of the following rules:

1. To determine heading when compass card is rotating back and forth in level flight:
   a. hold wings as level as possible and airspeed as constant as possible.
   b. then average the readings obtained at the extreme points of rotation of the compass card.
2. To determine the heading at which to begin roll out from a 3° per second turn:
   a. When a heading of north is desired, roll out of turn when the compass reads 30° short of north (See Diagram 2).
   b. When a heading of south is desired, roll out of turn after the compass has gone past south by 30°.
   c. When a heading of east or west is desired, roll out of turn when the compass reads the desired heading.
   d. To roll out on headings at intermediate points, undershoot or overshoot heading as shown in Diagram 2.

CAUTION: Do not exceed a rate of turn of 3° per second or the compass card may lock in position.

CONTROL OF THE AIRCRAFT

When you practiced the maneuvers in your Blue Seal training, you found that it was nearly impossible to hold all instruments exactly on the desired reading shown in the diagrams. In the airplane it seemed that at least one of the instruments always wandered away

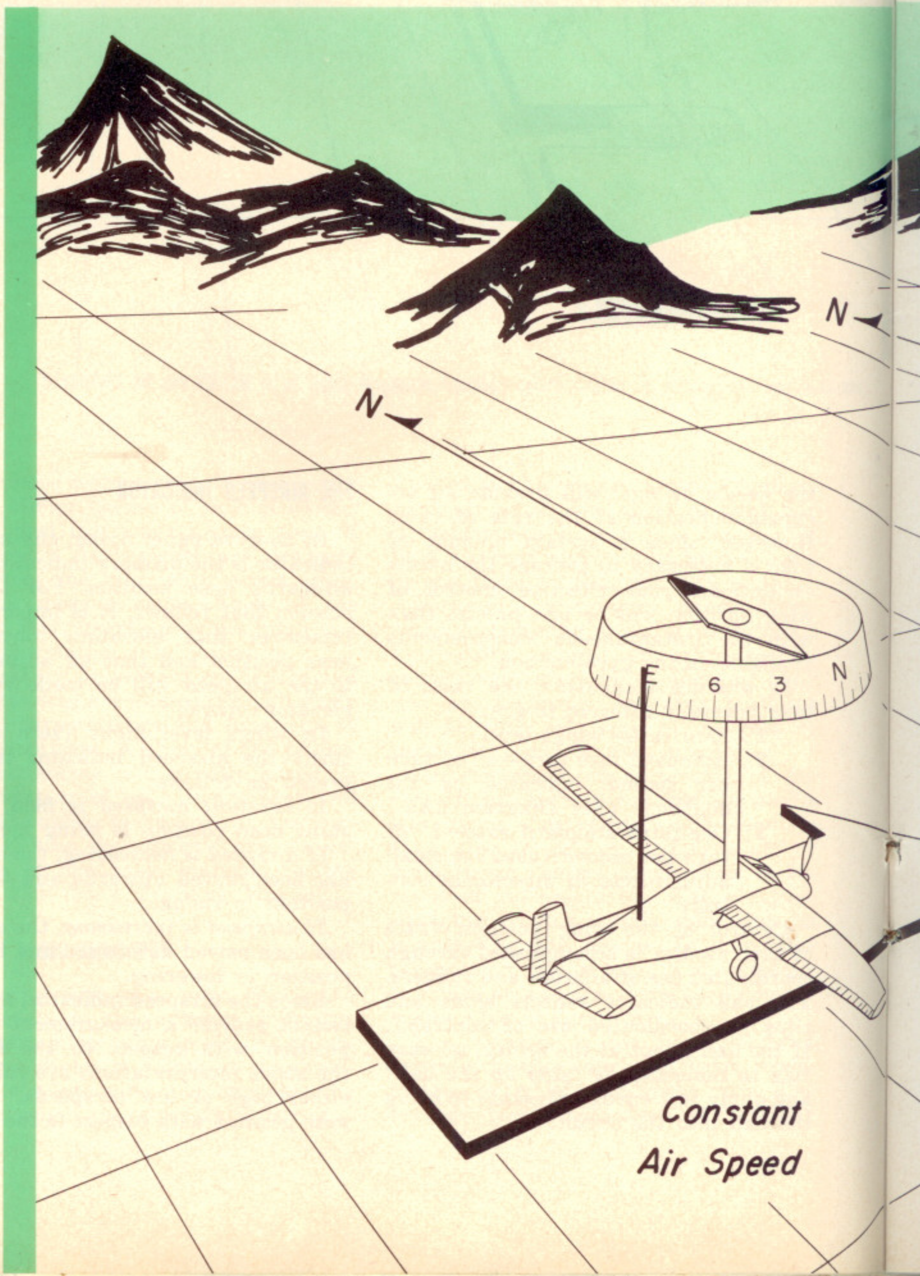


DIAGRAM 1C. Magnetic compass errors caused by turning and accelerations from the desired reading. The drifting and wandering of the instruments required "a continuous series of small corrections" to control the aircraft.

Your instructor prodded you to make adjustments by saying, "hold that heading," or "peg that airspeed," or "pin that attitude." What he really meant is "when you see an instrument off of a desired reading, make a small correction back to the desired reading."

Your instructor didn't actually mean for you to hold all the instruments steady. That is virtually impossible. Even the most experienced instrument pilots find their instruments drifting and wandering. Success in smooth, accurate control of the aircraft depends on *how soon* an instrument drifting away from a desired reading *is recognized* and then *how soon a small correction* is applied back toward the desired reading.

In this manual, any time a reference is made to "maintain," "hold," or "steady," it is intended to refer only to the *desired* setting or reading. It is assumed that the pilot will have to make continuous corrections requiring constant changes in control pressures and that he will constantly be adjusting back to the desired reading.

The early recognition of errors and the need for corrections applies equally to flying with visual references, with the master gyro-horizon and with a no-gyro panel. However, without the master gyro-horizon to set and adjust attitudes, the method and technique in obtaining information from the instruments as to aircraft performance must be modified.

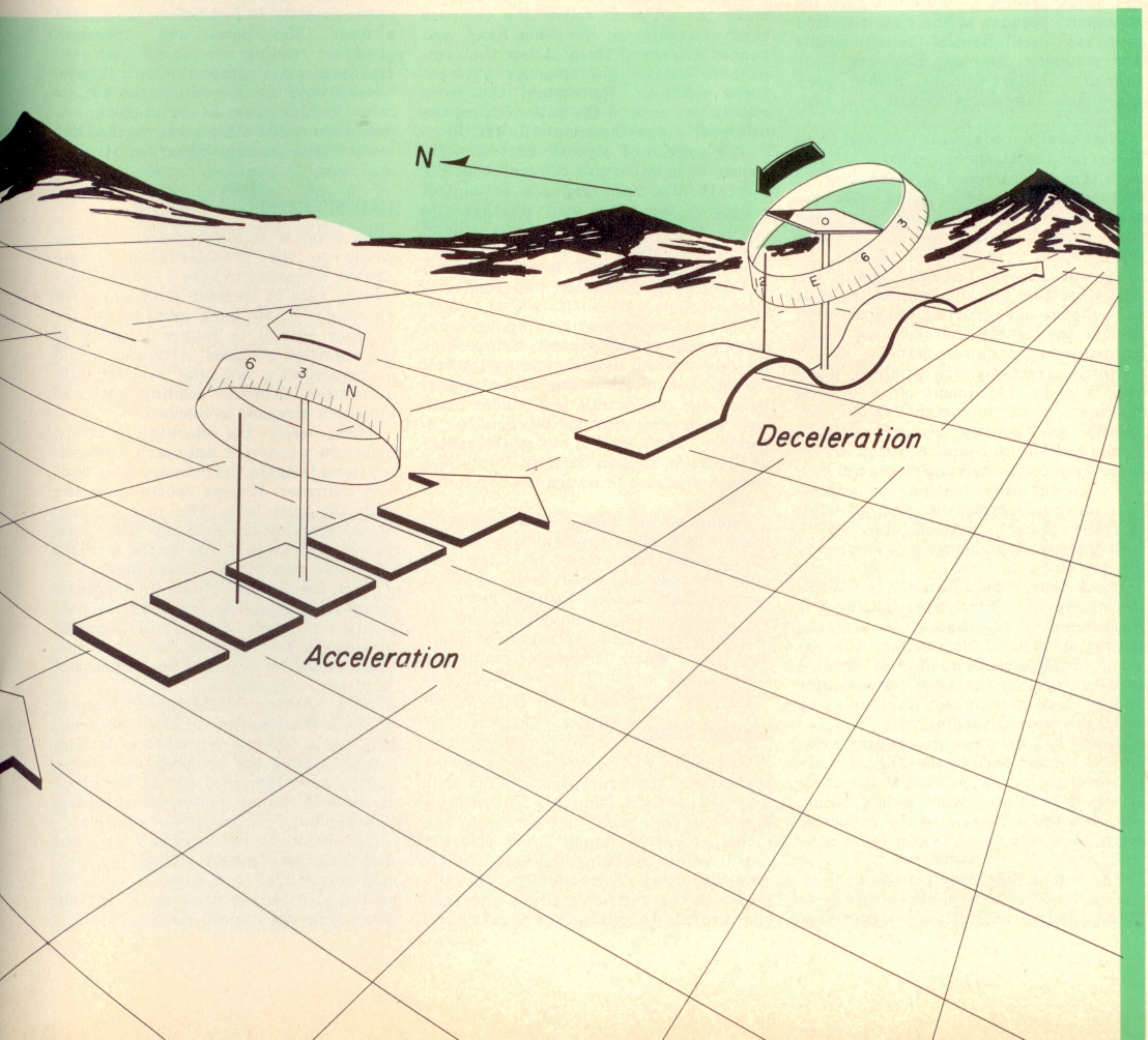
With a no-gyro panel for reference, obtaining information to control the aircraft becomes more complex since one instrument will not provide both nose and wing position information. It is necessary to look to two instruments. Even then, the two instruments used do not indicate nose and wing positions with respect to the horizon. Thus, it is difficult to mentally visualize the airplane's attitude.

Techniques for aircraft control with a no-gyro panel also require an increased pace of looking from one instrument to another to gather information similar to that available from the gyro-horizon. It is still necessary to recognize when the aircraft is drifting and wandering from the desired positions and to apply small corrective control adjustments.

Since wing and nose position information can not be obtained from one instrument, you must be careful not to spend too long looking at any one instrument while making adjustments or others will drift too far off.

PRACTICE MANEUVERS

The practice maneuvers for no-gyro panel reference instrument control are the same as used in the AOPA 360° Rating Course. This section describes the techniques and procedures for each maneuver. Practice of these maneuvers will provide the pilot with increased emergency instrument control capability. Carefully read these procedures, try to visualize each step, and root them



firmly in your mind. Knowing these procedures before you get into the plane will save precious instructional time in the air.

STRAIGHT AND LEVEL

For straight and level flight, the rate of turn needle is your primary instrument for wing position. Power setting is the primary control for altitude. The airspeed indicator is the primary instrument for nose position while the magnetic compass is the primary instrument for heading.

Your experience in flying with the gyro-horizon or in flying with visual references shows that, in coordinated flight, when the wings are kept level the aircraft will not turn. With the no-gyro panel, although there is no direct indication of wing position with respect to the horizon, a wings level position can be accomplished if you maintain an average of the turn needle oscillations on the zero rate of turn marker. This, of course, necessitates making small coordinated wing position corrections when the average needle oscillations drift from a center reading.

You will find that control of the aircraft's heading and wing position will not be as precise as with the gyro instruments because of the time required to average oscillations of the turn needle and magnetic compass. However, your over-all results will be within very reasonable tolerances as you gain proficiency.

Nose-position control is obtained from observing the airspeed indicator. If you note that the airspeed is decreasing or increasing, the nose is rising or lowering respectively. Elevator pressures must then be used to adjust the nose and airspeed to the desired reading.

If your airspeed has remained on the desired setting but you find that an altitude change has occurred, the correction back to the desired altitude must be accompanied by a power change.

How corrections are applied, when you note an instrument off a desired reading, is an important factor for smooth and precise aircraft control. *Beware* of the two most common errors in no-gyro panel instrument control:

1. Concentration too long on adjusting one instrument, and allowing the others to drift off, and
2. Over-controlling when making corrections.

Corrections should be made in the following manner: First, *stop whatever is happening*. In the case of an airspeed indication that is decreasing, for example, apply a small amount of elevator pressure to stop the airspeed indicator (nose) from moving any farther away from the desired reading.

Note: This does not mean apply pressure to correct *back* to the desired reading—*not yet*, anyway. This first correction is only to stop what is happening. The object is to determine the pressures required to stop the indicator from moving.

The second step requires the application of just a little more pressure to start the airspeed indicator (nose) moving back to the desired reading. Don't be in a rush to make a large correction. Using this two-step procedure will prevent over-controlling movements that result in overshooting the desired mark and can lead to endless "chasing the instrument."

This two-step procedure is used for wing, nose, altitude, and heading control. It allows time to observe other instruments while making corrections to one. After all, it takes some period of time for the eye to proceed from one instrument to another and back again, so proceeding with small, slow corrections is your key to smooth, precise control.

Care in trimming the aircraft is necessary for control. Upon reaching cruise altitude and airspeed, manually hold the control pressures necessary to maintain a constant airspeed reading. Then use the elevator trim tab to remove the control pressure. Do not attempt to change airspeed with the trim tab. Use manual pressure to set it, then remove pressure with trim. If aileron and rudder trim are available, use these to adjust for an efficient trim condition and to remove pressure.

The magnetic compass is used for directional control. Do not attempt to make the airplane follow the compass card rotations. On the other hand, you cannot disregard them. Allow the compass to rotate, and average at least three readings. Remember, the more closely you control the rate of turn, the less your actual heading will drift.

For continued smooth control techniques, it is important to recall that the aircraft flies and responds to control pressures the same way whether you obtain performance cures from ground references, from the gyro-horizon, or from a no-gyro panel. In all cases, coordinated use of aileron and rudder is most efficient.

Torque, improper rigging, or uncoordinated use of controls cause skids or slips and will be indicated by the ball moving out of the center trace. A ball out of the center tells you rudder pressure is needed. One simple rule to remember: If the ball is out of the center of the trace, step on the ball. Apply just enough pressure to return the ball to the center.

Rough air and lack of the one instrument which gives simultaneous and instantaneous indications of pitch and bank attitude will result in less precise control. Satisfactory results, however, can be obtained through early recognition of errors and application of many continuous small corrections similar to those made when flying with ground references or with a full gyro panel.

STRAIGHT CLIMB

The climb will be executed using the best rate-of-climb airspeed listed in your aircraft owner's manual. To enter a climb, apply back pressure on the elevator control. Apply climb power 5 m.p.h. before reaching the best rate-of-climb airspeed. Then stabilize the airspeed at the desired reading and trim the aircraft to relieve the pressure on the controls.

The primary instrument for nose position is the airspeed indicator. The primary instrument for wing position is the rate of turn needle. Don't forget that torque has the same effect when flying with instrument reference as it has when flying with ground reference. The effect of high angle of attack and low airspeed will tend to turn the aircraft to the left. Be vigilant in maintaining the "ball" in the center.

Directional control is indicated through an average of magnetic compass readings. The magnetic compass may tend to rotate as the nose position (airspeed) changes even though the airplane isn't actually turning. Continue to average the rate of turn needle oscillations on zero rate of turn indication. Allow the magnetic compass to rotate and average the readings before deciding a directional correction is needed.

When the airspeed and power have been steady for about 10 seconds, the vertical speed indicator is used to check the adequacy of the power setting. If a 500-feet-per-minute rate of climb is not being maintained, the power should be adjusted.

Level flight is regained by applying forward pressure on the elevator control approximately 20 feet before the desired altitude. Climb power and a constant altimeter reading are maintained until reaching cruise airspeed. Control pressures should be relieved by trim adjustment. Reduce power to cruise power setting when cruise airspeed is reached and make final trim adjustment for straight and level.

STRAIGHT DESCENT

To enter a straight descent, reduce power to the predetermined setting (power necessary to hold a 500-feet-per-minute rate of descent with approach airspeed). Apply back pressure on the elevator control to reduce airspeed to the approach airspeed. Airspeed should be reduced at a rate that will maintain a constant altimeter reading until the approach airspeed is reached.

Then, using the elevator controls, maintain a constant approach airspeed. Airspeed is again the primary nose position indicator. Relieve control pressure with the trim tabs. The rate of turn needle remains the primary wing position indicator, as it was in the straight climb and straight and level flight.

As in the straight climb, the magnetic compass may tend to rotate as the nose position changes. Patience is required to average the magnetic compass fluctuations before deciding an adjustment in direction is needed.

Refer to the vertical speed indicator to check the accuracy of the power setting for a 500-feet-per-minute descent, but only after the airspeed and power setting have remained steady for about 10 seconds. Adjust power, if necessary, to achieve the proper rate of descent.

Corrections of headings and wing and nose positions should follow the two-step procedure. If a wing is lowering or the airspeed or heading is drifting away from the desired reading:

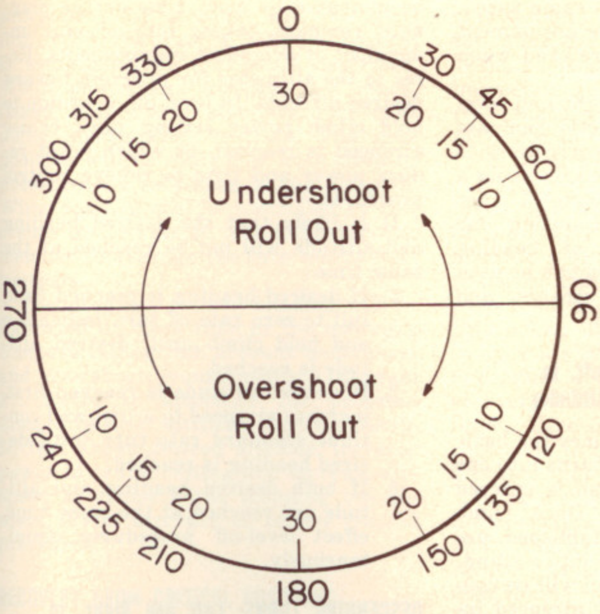


DIAGRAM 2. Adjust roll-out headings to compensate for turn errors on the magnetic compass

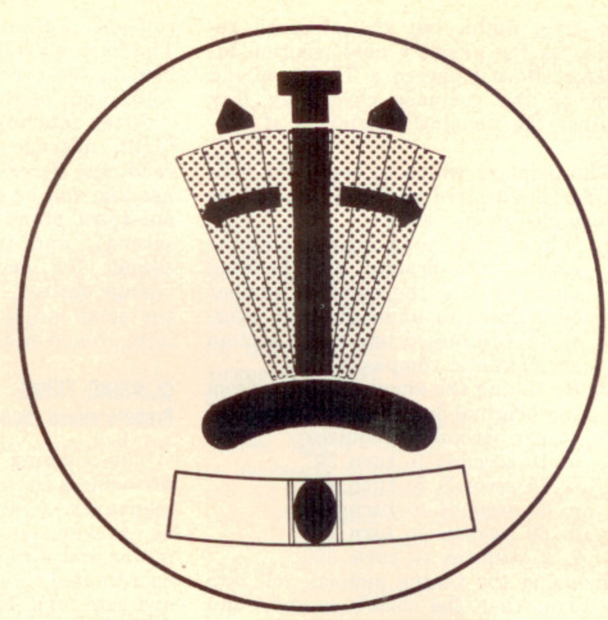


DIAGRAM 3. Average the oscillations of rate of turn needle

Step 1. Apply control pressures to stop the drifting or indicator movement.

Step 2. Apply small additional pressures to correct back to the desired position.

Note: These pressures should be prompt and smooth, but small. Don't over-correct or chase instrument needles.

To return to level flight, add cruise power approximately 50 feet above the desired altitude. As the altimeter begins to level off, apply forward elevator pressure to increase airspeed to the desired reading. Retrim the aircraft for straight and level flight as the airspeed reaches cruise airspeed. Changes in airspeed must be made with manual pressures. Do not attempt to change airspeed with trim tab alone. Trim tabs only remove pressures you have had to hold to obtain the desired reading.

STANDARD RATE, Level Turns—Left and Right

The standard turn used in instrument flight is a 3°-per-second turn (a 360° turn takes two minutes). This rate is marked on the turn indicator by a "doghouse" on either side of the center mark.

When the oscillations of the turn needle average on a "doghouse," the turn rate is 3° per second, *regardless of your airspeed and angle of bank.*

To enter a standard rate turn, use coordinated aileron and rudder pressures until the average needle fluctuations indicate on the "doghouse." The turn needle remains the primary wing position indicator throughout all turns.

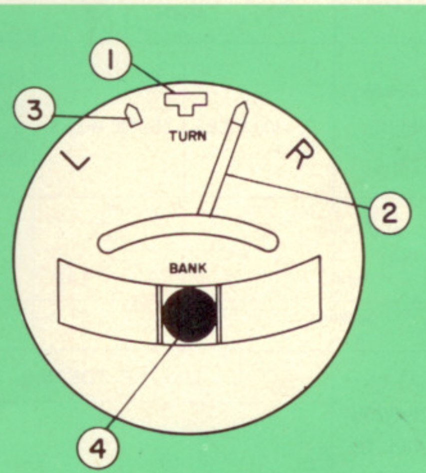
As the aircraft begins to turn, elevator pressure must be applied to adjust the nose position slightly upward. The elevator change is necessary to compensate for the centrifugal force created by turning. Check the altimeter to determine if sufficient compensation has been made.

Airspeed in the turn will be a few miles per hour slower than in straight

DIAGRAM 3A.

Turn and Bank

1. Zero rate of turn index — Straight flight.
2. Turn needle — Deflects in the direction of turn or under center post indicating zero rate of turn.
3. Three degree per second rate of turn index — "doghouse" — NOTE: Needle deflected to right aligned with doghouse indicating standard rate turn to the right.
4. Ball indicator — Indicate slipping or skidding.



and level flight, but the airspeed remains as the primary nose position indicator. Do not exceed a 3° per second turn or the compass card may lock against the housing, rendering it useless.

The point at which to begin the rollout for the desired new heading can be determined in two ways:

1. When the magnetic compass reaches the desired new heading plus or minus the required number of degrees to undershoot or overshoot (discussed under the section on magnetic compass).
2. By timing the amount of turn from the original heading. At a rate of 3° per second, it requires:
   a. 10 seconds to turn 30°
   b. 15 seconds to turn 45°
   c. 30 seconds to turn 90°
   d. 60 seconds to turn 180°
   e. 2 minutes to turn 360°

In using the timing method, roll into the turn when the clock's second hand is "straight up." For a turn of 180°, the roll out should begin when the second hand is straight up again. Care should be exercised to keep the roll into and roll out of the turn at the same speed. The back elevator pressure adjustment held in the turn must be relaxed when rolling out of the turn.

After returning to straight and level flight, average the magnetic compass readings. Necessary small corrections to heading can be accomplished by using a one-third standard rate turn (1° per second), and timing or counting one second for each degree of heading change desired. This method can be used for small adjustments in straight and level climbs and glides also.

CLIMBING TURNS: Right and Left, to Predetermined Headings and Altitudes

The climbing turn combines the basic procedures for climbs and turns into one maneuver. A straight climb is entered as previously described. Once climb power and airspeed are established, use coordinated controls to roll into a standard rate turn. Nose position will be controlled by reference to the airspeed indicator; wing position by reference to rate of turn indicator.

Progress to the desired heading will be indicated by clock time or the magnetic compass, taking into account undershoot or overshoot requirements. Refer to the altimeter for progress toward desired altitude. In level off, continue to hold climb power setting until cruise airspeed is reached, at which point reduce power and trim to relieve control pressures.

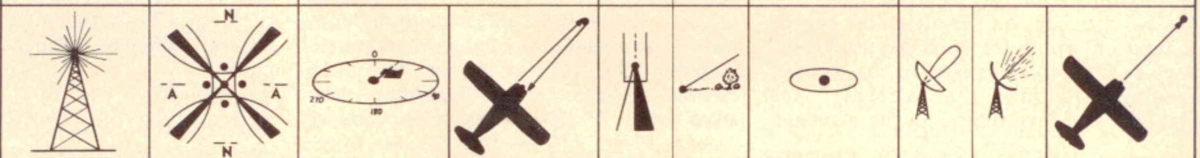
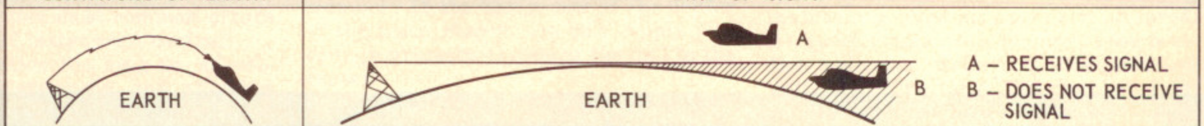
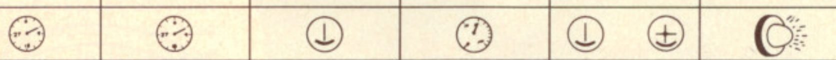
It is likely that the desired heading and altitude will not be reached at the same time.

1. If desired heading is reached first, roll to zero rate of turn indication and hold climb until desired altitude is reached.
2. If desired altitude is reached first, increase airspeed to cruise and continue standard rate turn until desired heading is reached.
3. If both desired heading and altitude are reached at the same time, effect level-off procedures simultaneously.

DESCENDING TURNS: Left and Right, to Determined Headings and Altitudes

The descending turn combines the

DIAGRAM 4. Comparison of Navigation Aids

NAV. AID Characteristics	HOMER AND OUTERMARKER	LOW FREQUENCY RADIO RANGE	VHF OMNI RANGE	DISTANCE MEASURING EQUIPMENT	INSTRUMENT LANDING SYSTEM: LOCAL-IZER	INSTRUMENT LANDING SYSTEM: GLIDE-SLOPE	MARKER BEACON	RADAR: Search	RADAR: Height	DIRECTION FINDING
	LOW FREQUENCY BAND		VERY HIGH FREQUENCY BAND							
FREQUENCY	200–415KC	200–550KC	108.1–117.9MC (960–1215MC)		108.1–111.9MC	331.1–335.0MC	75MC	108.1–135.9MC		
SIGNAL PROPAGATION										
PATH THAT RADIO SIGNAL FOLLOWS	CURVATURE OF EARTH		LINE OF SIGHT							
										
MAXIMUM USEFUL DISTANCE	25–100 MILES	50–100 MILES	1000'–45 MILES 3000'–80 " 5000'–100 " 8000'–140 "	115 MILES	40–50 MILES		5 MILES	35–100 MILES	10 MILES	100 MILES
Methods of Presenting Useful Information To Pilot: Visual										
Aural		EAR					EAR			
Spoken Word								HEADPHONES		
NAVIGATIONAL INFORMATION PROVIDED TO THE PILOT	LINE OF POSITION				LINE OF POSITION					
				DISTANCE			DISTANCE			
							FIX			

procedures for descents and for turns into one maneuver. A straight descent is established as previously described. When power and airspeed are established, roll into a standard rate turn using coordinated controls. The nose position will be controlled with elevator pressures by reference to the airspeed. Wing position will be controlled by reference to the rate of turn indicator. Remember to average the turn needle fluctuations.

The progress toward heading will be indicated by clock time or the magnetic compass taking into account undershoot and overshoot requirements (Diagram 2). Refer to altimeter for progress toward desired altitude. Approximately 50 feet above desired altitude, increase power to cruise setting and increase airspeed to cruise while stopping the descent. Trim aircraft to relieve control pressures.

RECOVERY FROM CRITICAL POSITIONS

In a situation where the non-instrument rated pilot may inadvertently lose all visual reference, the aircraft can proceed into a critical position before the pilot can get "onto the gauges." When he does, the situation demands an immediate and accurate recovery. It is recommended that these recoveries be practiced in case it is necessary to perform them when his life is at stake.

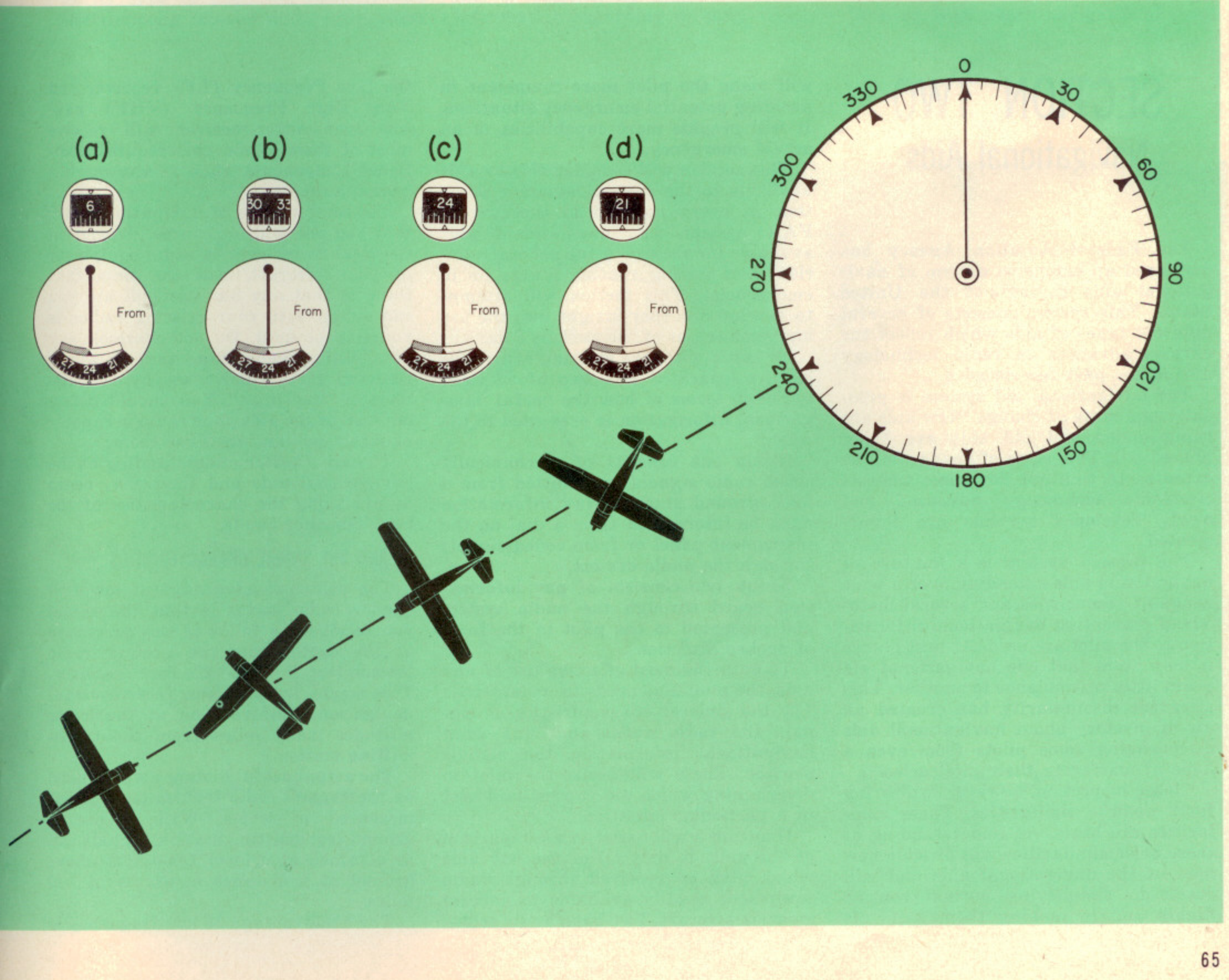
During the course, the pilot will be instructed to take his hands and feet off of the controls and close his eyes. The aircraft will then be put into a critical position. This position may be an approach to a stall or a spiral dive. At this point, the pilot will be instructed to open his eyes, take over the controls, and effect a recovery. *In all cases*, the recovery will be to straight and level flight. Recoveries will be executed by reference to the rate of turn indicator, airspeed indicator, and altimeter.

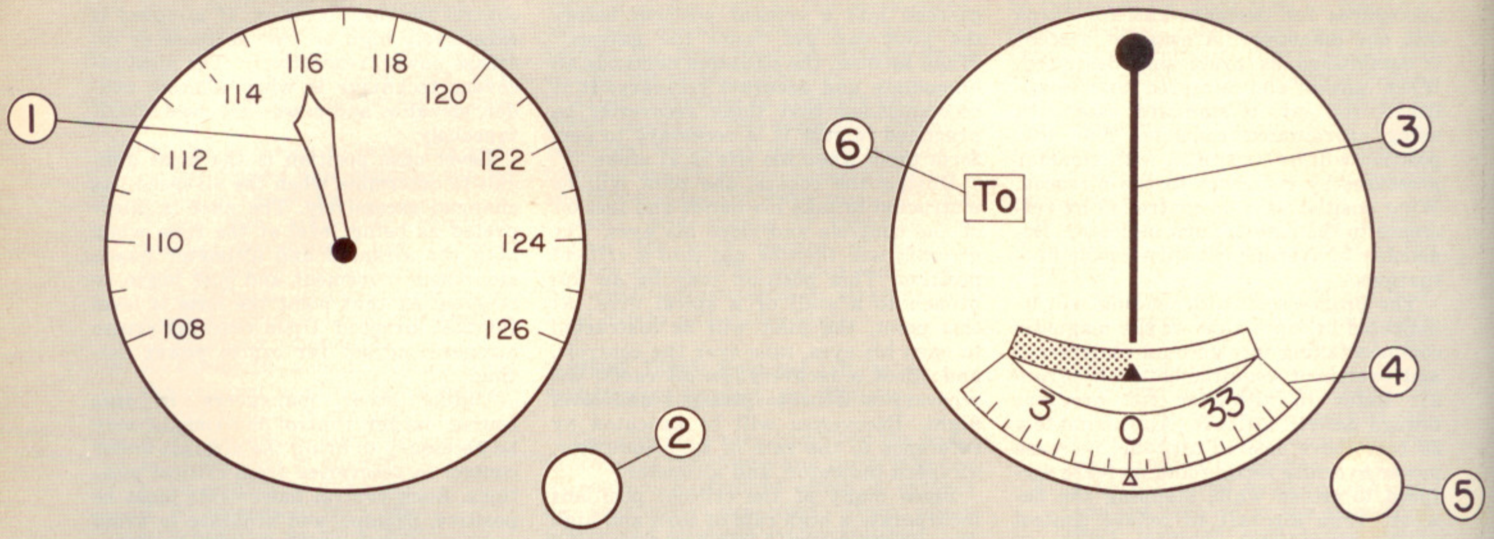
Since many of the critical positions incorporate a high rate of turn and high wing loadings, it is important that the recovery be accurate and prompt. When first taking over the controls, glance at the turn needle. Use coordinated ailerons and rudder to return the turn needle to zero rate of turn. Glance at the airspeed and use elevator pressures to control the nose position. If airspeed is excessively high or low, decrease or increase power, respectively. The ideal recovery technique is when aileron, rudder, elevator, and power are used simultaneously.

Level nose position is the most difficult to determine when the airspeed has changed excessively. The nose is interpreted as being level at the time when both the airspeed and altimeter hands stop their movement and just begin to reverse. At that point the nose is level for that airspeed. Upon reaching cruise airspeed, adjust for cruise power setting.

Unlike other maneuvers in this course, larger control movements may be necessary to bring the aircraft under control in recoveries from critical positions. Such control movements must be positive, prompt, and accurate to avoid aggravating the critical attitude with a control application in the wrong direction. The interpretation of instruments must be correct. Once the aircraft is returned to approximate straight and level flight, control movements should then be of the small adjustment type.

DIAGRAM 5. Line of position





1. VHF Receiver Frequency Indicator
2. Receiver Tuning Knob
3. Course Indicator
4. Radial Indicator
5. Radial Selector Knob
6. TO-FROM Indicator

DIAGRAM 6. VHF Radio

SECTION TWO
Navigational Aids

The Federal Aviation Agency has developed an extensive system of navigational aids throughout the United States. This system consists of several different types of aids which reflect the various advances in radio technology during the past few decades.

The navigational aid system is presently in a state of change. New aids are being added and old aids are being phased out. This state of change can be expected to continue for some time as electronic technology advances and newly developed systems are implemented.

The present system is a mixture of navigational aids extending over a wide range of frequencies and several methods of presenting navigational information to the pilot are used. At first glance it may seem that one navigational aid bears little resemblance to another. This apparent dissimilarity has created an air of mystery about navigational aids discouraging some pilots from even a hope of mastering their intricacies.

Closer inspection, however, will bring forth *definite* similarities. These similarities are basic. An understanding of these basic similarities will provide new uses of the navigational aids and will result in simplifying normal routine flights and in making them safer. It will make the pilot more competent in avoiding potential emergency situations. It will provide more capabilities in an actual emergency.

This section will consider *all* nav aids available to the general aviation pilot; that is, every nav aid in the current FAA system, i.e., navigational aids available for the use of the general aviation pilot during routine flights or in emergencies. This section will attempt to develop a deeper insight into the use and similarities of the various aids.

To begin with, the existing radio aids can be separated into two broad categories in terms of how the useful navigational information is presented to the pilot.

Group one consists of mechanically coded radio signals transmitted from a fixed ground station. Nav information must be interpreted from a dial on the instrument panel or from coded signals through the audio system.

Group two consists of nav information heard through the audio system and presented to the pilot in the form of spoken directions.

To gain the most effective use of nav aids, the pilot also needs to understand: (1) the general characteristics of signals and radio waves and; (2) what navigational information the signals provide. These will assist the pilot in determining which aid can be used best in a particular situation.

Diagram 4 will assist in a comparison of the aids. It lists all of the nav aids which may be received through radio equipment readily available to general aviation aircraft. Two basic radio sets—the Low Frequency (LF) receiver and Very High Frequency (VHF) nav/com transmitter-receiver will receive most of them. Some aids require additional components, such as the marker beacon antenna.

The total number of navigational aids that you use will, of course, depend on the total investment in radio equipment in your aircraft. But the important thing is that any navigational aid you can obtain with your existing radios is yours to be used. Do not overlook any possibilities; understand that no aid is reserved for exclusive use by the airlines or "the pros." You should determine all of the aids your radio is capable of receiving—and then use them.

To gain a better understanding of the navigational aids and their use, begin by analyzing the characteristics of the two frequency bands.

LF AND VHF SIGNAL CHARACTERISTICS

The principal advantage of low frequency radio waves is that the signal you receive has followed the curvature of the earth from the ground radio transmitter to the aircraft receiver. This means the pilot can receive useful navigational information at the lower altitudes many miles from the transmitting station.

The actual useful distance will depend on the ground radio transmitter output measured in watts. With a strong ground transmitting station, signals can be obtained at a level 1,000 feet above ground at a distance in excess of 100 miles.

The disadvantage of low frequency is

its high amount of static when atmospheric electrical disturbances are present. This static is of a degree that can render the radio useless to receive navigational signals or communications.

The signals received on your VHF radios have followed a "line of sight path." The principal advantage of VHF is its freedom from static.

It can be used for communications and navigational signals during atmospheric disturbances such as thunderstorms. However, when a signal follows a line-of-sight path, any obstacle between the ground transmitting station and the aircraft, such as a mountain or the earth (shown in the grey area of Diagram 4), will block the signal. Its useful distance depends not only on transmitting power, but also on the aircraft's altitude with respect to the transmitting station.

TYPES OF NAVIGATIONAL SYSTEMS

Each transmitter (for the navigational aids listed in Diagram 4) has individual characteristics in the design and type of electronic navigational signal it sends out. These individual characteristics require receiving antenna systems and radio receivers matched to the signal emitted from each different type of ground transmitting station.

Each navigational signal is captured by its type of receiving antenna and electronically relayed to the radio black box in your aircraft. The black box takes the signal, converts it electronically, and presents it to the pilot. The way the signal is presented to the pilot will depend upon the characteristics of the signal originally sent out by the ground station. Individual systems will present their navigational information on a dial, needle, or as distinct sounds.

This may seem complex. Yet, there are but two kinds of useful navigational information that radio aids give the pilot. These are: (1) Distance measurements, and (2) Lines of position.

It is important at this point to understand what these two kinds of information provide the pilot.

A distance measurement, such as shown by distance measuring equipment (DME), simply provides a distance from a particular station. A distance measurement by itself cannot be assumed to provide any directional information with respect to the station. That must come from a line of position.

A line of position (LOP) is defined as a line that passes through a known geographic point and in a known compass direction. In radio navigation, the reference "being on a line of position" means that an aircraft is somewhere on a known radio line (radio bearing or radial) that passes through a known radio station. It is emphasized that the line of position by itself provides no information regarding distance from a station; nor does the compass direction of the LOP have any relationship to your aircraft heading.

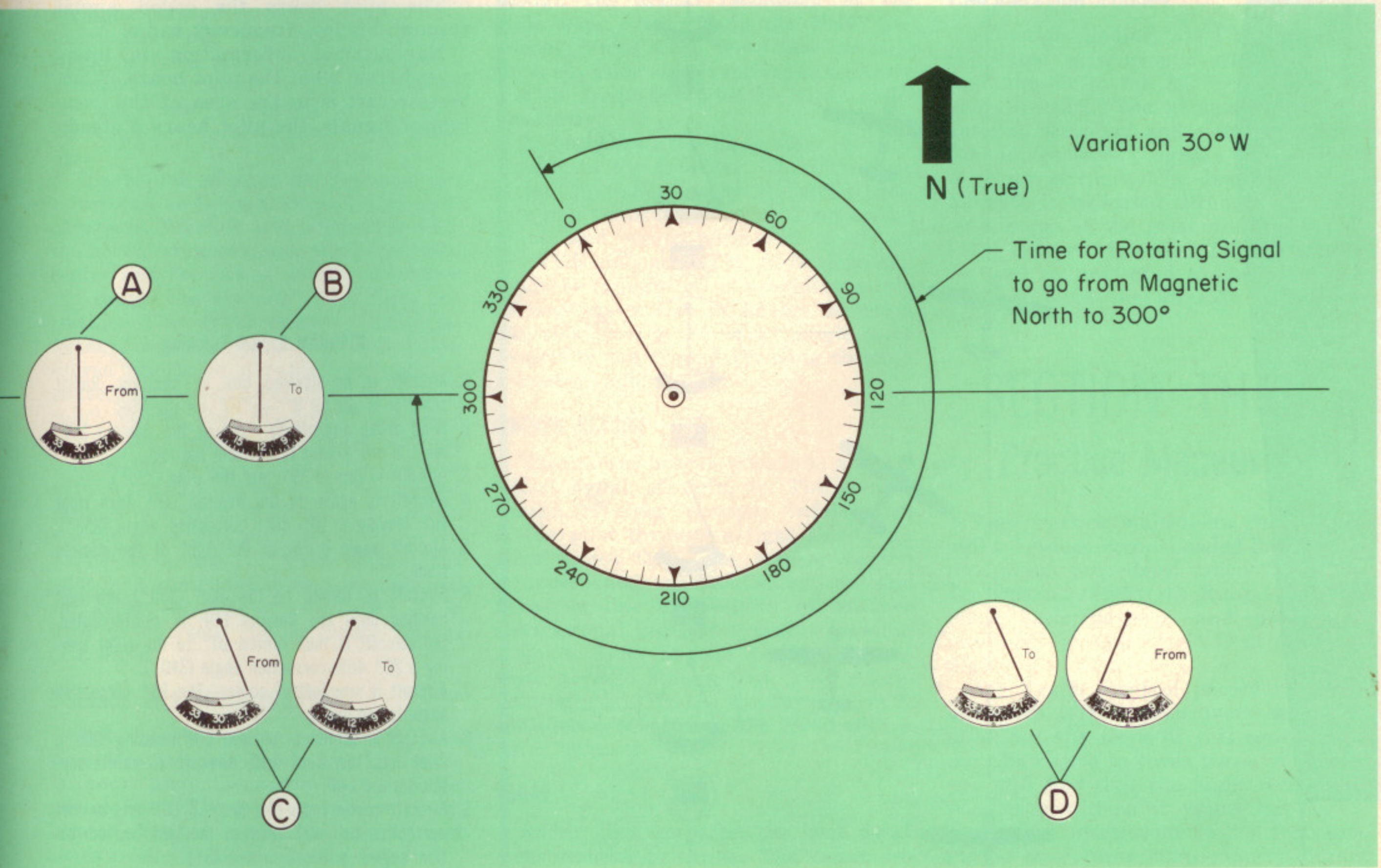
For example, in Diagram 5, aircraft a, b, c, and d are on the same LOP; that is, on a radial of 240° from radio station APE. They are on different headings, and at different distances from the radio station, but on the same LOP.

For the pilot, one of the most important aspects of navigation is being able to positively fix your aircraft's position. A fix is defined as positive identification of position at a known geographic location. This can be accomplished by using combinations of distances and LOP's. A fix in radio navigation is determined by:

1. The point at which you pass directly over a *known* radio station.
2. By being a known distance out on a LOP. (For example: being positioned on a VOR radial with a DME distance measurement.)
3. By the intersection of two or more lines of position. (For example: where two lines of position from two different VOR's intersect, such as the intersection of two different airways; or the intersection of an ILS localizer and a direction finding line of position.)

The next step is to develop a general understanding of the listed navigational aids. Signal characteristics and the manner with which navigational infor-

DIAGRAM 7. VOR Course Indications



mation is presented to the pilot follow. This is background information to determine that most important feature—the navigational information the pilot receives—whether it is distance, LOP, or fix information. The section following this one will apply this information to instrument flight procedures.

LOW FREQUENCY HOMERS

The homer has a single antenna that transmits its signal in all directions and at equal strength. The automatic direction finding (ADF) used in conjunction with the low frequency receiver seeks out this signal and points to the station. The information is presented to the pilot through the ADF needle which points to the station and measures the direction to the station in degrees relative to the aircraft's nose.

To determine the magnetic heading to the station, observe the number of degrees under the pointer of the ADF needle. Add this number to the aircraft's magnetic heading. This sum will provide the magnetic heading to the station. Since the geographical position of the station is shown from the navigational chart, you can determine LOP (known heading and known station) information.

LOW FREQUENCY RADIO RANGE

The low frequency radio range has four antennas. Each antenna transmits a directional signal that is coded as either an "A" (.—) or an "N" (—.). The signal for each antenna slightly overlaps those of the adjacent antennas (see Diagram 4).

The pilot hears the coded signal through his low frequency radio.

Navigational information is interpreted from what the pilot hears. When the aircraft is in the area of the overlapped signals, the pilot hears a steady

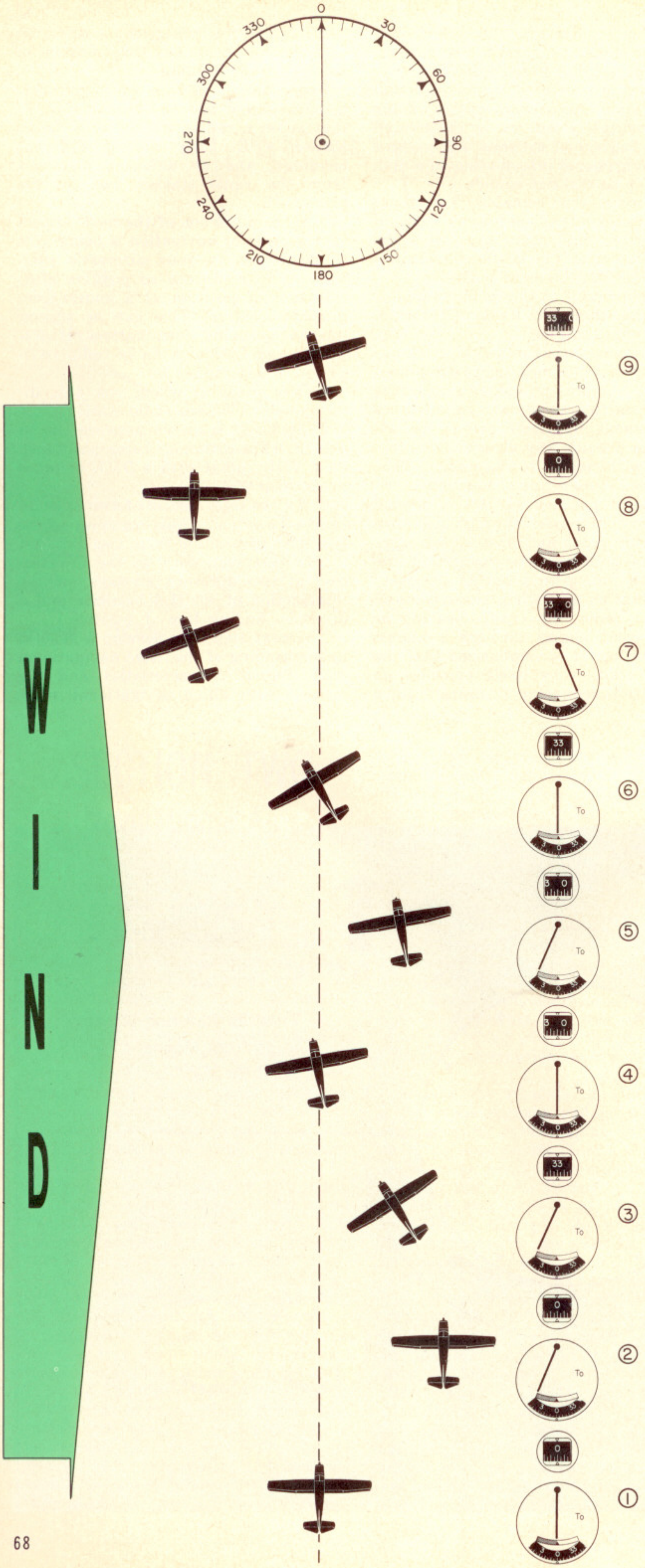


DIAGRAM 8. VOR Tracking

1. Aircraft is on desired line of position. Radial selector is set for 0° — "TO" on the VOR.
2. Wind drifts aircraft to right of the desired LOP. Wind is now known to be from the left.
3. Aircraft is turned 30° into the wind (330°).
4. Aircraft is again on the desired LOP. Turn right 20° leaving a 10° drift correction angle (350°).
5. Aircraft again drifts to the right of the desired track.
6. Aircraft is turned to the 30° (330°) interrupt heading until the desired LOP is reintercepted, the aircraft is then turned 10° to the right leaving a 20° drift correction angle (340°).
7. Aircraft is now left of course. The 20° correction angle is too much.
8. Aircraft is turned to desired LOP heading (000°). Pilot lets the wind drift aircraft to reintercept the desired LOP.
9. Aircraft reintercepts the desired LOP and a drift correction half way between the last two correction angles is maintained (345°).

tone formed when the spaces in the "N" signal are filled with the "A" signal. Outside the overlap area, the pilot hears either an "A" or an "N."

The four areas of steady tone are known as the "on course" legs of the four course range. Magnetic compass direction of the legs of each station are shown on the navigation charts. So, if the pilot hears an "on course" signal, he is on one of four lines of position; that is, on a leg with a known heading to a known radio station (to determine which leg he is on, other information must be obtained). ADF equipment will seek the center of the station and can be used as described above.

VHF OMNI RANGE

The following discussion of the Very High Frequency Omni Range (VOR) does not attempt to analyze electronic circuitry. It will provide a general description of the mechanics of the VOR.

The VOR radio station emits two electronic signals. One is a directional signal that rotates like a one-sided airport beacon. The other, a master reference signal, is emitted in all directions continuously.

The master signal has a varying intensity and is at its peak just as the rotating signal passes through one specified heading. The VOR receiver in the aircraft can be thought of as a measuring device. It measures the elapsed time from the instant it receives the peak master signal until it receives the rotating signal. The black box "knows" the speed at which the rotating signal travels and the heading where the master signal peaks. Thus, by measuring time elapsed from master to rotating, it can "tell" how far the rotating signal is from North. This time measurement information is converted electronically and presented to the pilot through the course needle on the omni head.

The radial selector on the omni receiver can be thought of as a time synchronizer. When it is synchronized with the actual time elapsed, the needle will center and the radial selector will show the radial the aircraft is on from the station. The synchronizer (radial selector), however, will also center the course needle on a radial 180° out of phase, but a second circuit in the "black box," called the "to-from" indicator switch, will indicate the radial change.

In either case, we again have a line with a known direction which passes through a known radio station, providing the pilot with an LOP.

The advantage of VOR is that the pilot isn't restricted to four courses and can select any one of 360 LOP's. It is used extensively for en route phases of a flight.

DISTANCE MEASURING EQUIPMENT

Distance measuring equipment is a time delay measuring device. The radio in your airplane sends out a coded signal first. The ground station is activated by the aircraft's signal and sends back its coded signal.

The DME "black box" electronically measures the time delay between sending and receiving the signal, converts the measurement and presents the information on a gauge which the pilot reads as distance, in nautical miles.

To do this, the DME radio "knows" the speed at which the signal travels out and back and can convert the time to distance traveled. For convenience, the frequency tuned on the DME receiver is the same as the published VOR frequency (although the actual frequency of the signals is in the UHF frequency band). The only information the DME presents is distance from a station.

INSTRUMENT LANDING SYSTEM—Localizer

Most of the VOR radios installed in general aviation aircraft receive the localizer by simply tuning to the published localizer frequency.

On some sets, it may also be necessary to change a selector switch from a VOR position to a Localizer position. In either case, the VOR course needle is used to indicate the localizer course.

The localizer is similar to the VHF omni range except that it indicates only one course. It provides the pilot with a known direction and known station—thus a line of position. This LOP has a shorter range than a VOR and is designed to be used in a terminal area to direct the pilot to a specified runway.

INSTRUMENT LANDING SYSTEM—Glide Slope

The glide slope system is normally activated when the localizer frequency is tuned on the VHF receiver, although the actual frequency of the glide slope system is in the UHF frequency range. On a few radio installations the glide slope receiver is separate and its frequency must be tuned independently.

In operation, the glide slope is very similar to the localizer. The difference is that it indicates the aircraft's position in a vertical rather than horizontal plane, and uses a horizontal needle on the VOR indicator. The glide slope can again be thought of as providing a line of position—a line of known direction (in this case, a 2° to 3° angle with respect to the ground) passing through a known radio station.

MARKER BEACON

The marker beacon transmits a directional signal, straight up. The marker beacon receiver presents information to the pilot through a light and/or an aural coded tone. The marker beacon is positioned perpendicular to and across a line of position of another navigational aid and indicates passing a point. Since it is a known distance from a radio station and is on a predetermined LOP, the marker beacon is considered to provide the pilot with a fix.

RADAR

Radar also works on the time delay measurement principle. The radar antenna sends out an electronic signal that bounces off of an obstacle (target) and returns to the antenna.

The radar "black box" knows the speed of the signal and measures the time it takes for the electronic signal to go out and return. This is converted to a signal that appears on the radar screen showing both direction from a known point (the radar antenna) and the distance to the target. The radar, then, provides a known LOP and a known distance, which is a fix.

This navigational information is relayed from a ground observer to the pilot through the spoken word. It is received on the VHF radio by tuning to one of the proper communications frequencies.

There are two types of radar in use —search and height finding.

A search radar antenna rotates in a horizontal plane and provides directional (azimuth) and distance information. This is used at Airport Surveillance Radar (ASR) sites, en route radar sites, and is one part of all Precision Approach Radar (PAR) sites.

Height-finding radar is the second component of a PAR site. Its antenna sweeps up and down and provides the distance of the target vertically above the ground and horizontally from the antenna.

The combination of search and height-finding radar is used to guide the aircraft very precisely toward a specified runway. It actually provides a precise three-dimensional fix of direction and distance both horizontally and vertically from a known point.

VHF DIRECTION FINDING

Direction finding (D/F) equipment is located at a ground station and is very similar to the ADF equipment in your aircraft. The ground-based D/F antenna seeks out and points to a VHF communications signal transmitted from an aircraft. The direction to the aircraft is indicated through a pointer on a scope at the ground station. This LOP (known direction from a known station) is presented to the pilot verbally through the aircraft's VHF receiver.

SECTION THREE
Practice Maneuvers

The practice maneuvers that follow will introduce recommended basic radio navigation procedures when flying under Instrument Flight Rules. They include basic patterns and procedures required by Air Traffic Controllers in flight.

Air Traffic Control procedures spell out when certain maneuvers are to be used, but the scope of this course does not allow time to cover these. However, you will find that the flight techniques you learn will be of value and assistance when using your radios for navigation on routine cross-country flights under Visual Flight Rules and will be of great benefit in an emergency situation.

Since the VHF Omni Range (VOR) is the primary navigational system, you will use the VOR radio equipment for practicing the maneuvers.

It was found in the preceding section that the navigational information provided by the VOR was the LOP. All the maneuvers are based on use of the line of position. However, the procedures would remain the same regardless of the piece of radio equipment used to provide the LOP. The only difference between the VOR and any other radio aid would be the interpretation of the indicator or aural code providing LOP information.

Before beginning the maneuvers, a review of VOR radio equipment and how the indicators are interpreted is suggested. Diagram 6 is a picture representing VOR radios available in general aviation aircraft.

As mentioned previously, the big advantage of VOR navigational aids is that any one of 360 LOP's can be selected for navigational use. To assist the pilot in using these 360 LOP's, the navigation charts show a compass "rose" around each VHF omni range. The compass rose then shows the magnetic headings for the radials coming out from the center of the station. You can select the radial you wish to use by simply adjusting your radial selector.

Your radial selector is, as mentioned before, a time synchronizer. When, for example, you wish to use a radial of 300, you place 300 under the pointer on the radial selector. This electronically sets the amount of time that should elapse between receiving the peak master signal and the rotating signal at 300°. Then, if the actual time lapse is identical to what you have set into your radio circuit, *the Course Indicator will center* and *"From"* will show on the "To-From" indicator (see Diagram 7A).

If, on the other hand, you set the radial selector 180° out of phase, i.e., on 120°, and the VOR actually measured the elapsed time of the 300° radial, *the Course Indicator will again center*, but a "To" would show on the "To-From" indicator (see Diagram 7B).

This is an outstanding design feature. If your aircraft is positioned on the radial as shown in Diagram 7, the needle representing the desired line of position is centered and immediately provides the heading to fly "To" the station (120° magnetic) or the heading to fly "From" the station (300° magnetic). These are, of course, no-wind headings.

Pictures of aircraft were not drawn around the indicators because it is important for the pilot to remember that the VOR radio only measures elapsed time between two electronic signals. When the aircraft is positioned so the actual elapsed time is identical to the elapsed time measurement set into the radio, the course needle will center regardless of the aircraft's magnetic heading.

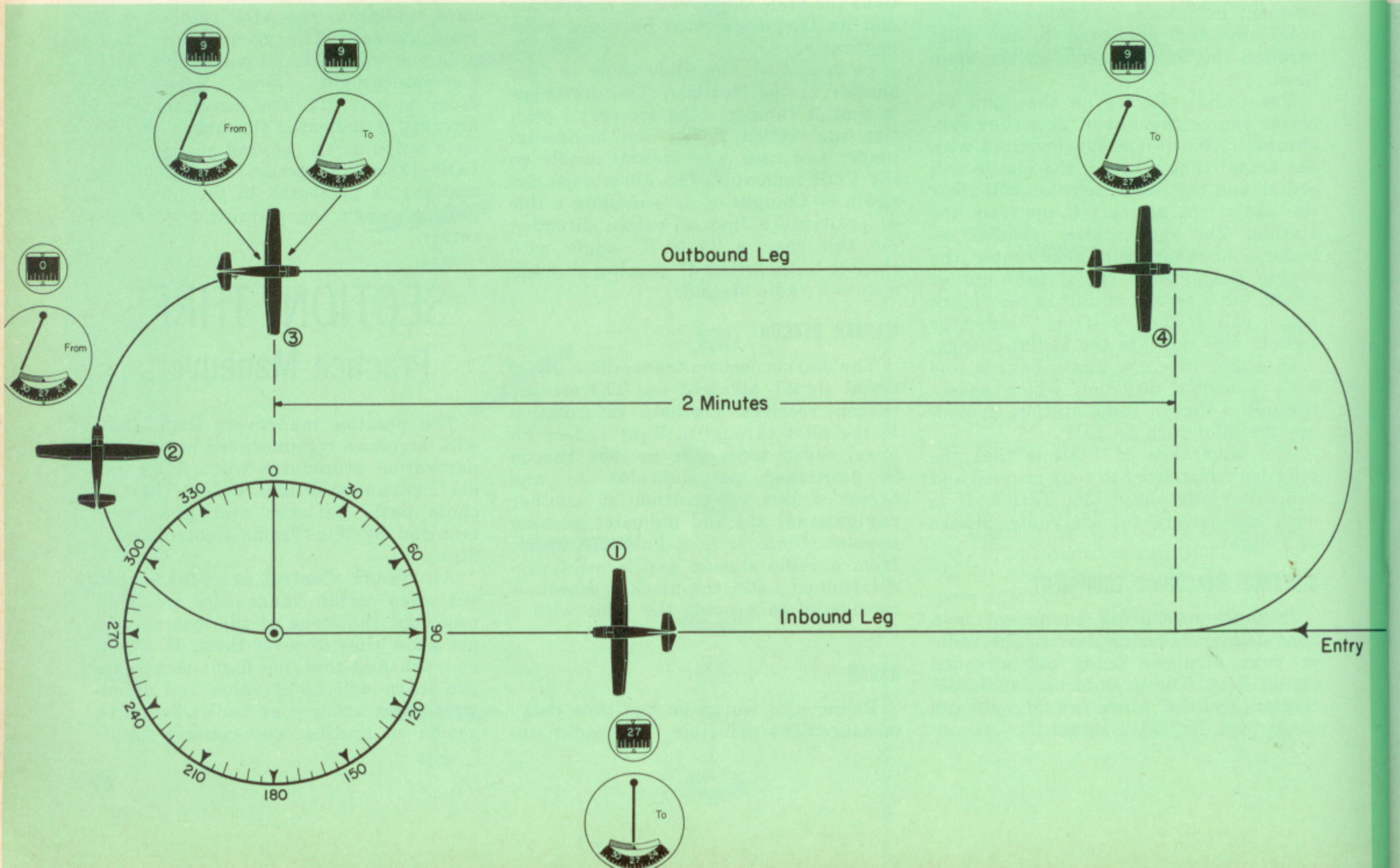
One feature designed into the course indicator needle does bear a relationship to aircraft heading: that of pointing to the radial if the aircraft is not positioned directly on the radial.

The course indicator needle is designed so that when your *aircraft's magnetic heading* and the *radial selector are the same* (or at least in general agreement), the needle will swing to

DIAGRAM 9. Holding Pattern

1. Aircraft is inbound to the station on the desired Line of Position. A "TO" indication is used on "TO-FROM" indicator. Correct for wind drift.
2. As the aircraft passed over the VOR Station, "TO-FROM" indicator changed to a "FROM" indication. Immediately after passing the Station a 180° standard rate turn to the right is started.
3. The "TO-FROM" indicator changes to read "TO" as the aircraft proceeds outbound. On the outbound leg hold an approximate wind drift correction to prevent the aircraft from drifting too far off the intended leg.
4. After two minutes on the outbound leg a standard rate 180° turn to the right is started. As the aircraft intercepts the inbound LOP, correct for wind drift.

NOTE: At all times in the holding pattern, except when inbound to the station, the course needle points to the left.



the side and point in the direction to correct to the desired radial (LOP).

For example, in Diagram 7, mentally visualize yourself in an aircraft on a magnetic heading of 120° flying from left to right. If you are off course, as indicated by C or D, the course indicator needle indicates that you must go to the left to get onto the desired radial. Note that the course indication needle *does not reverse* as you pass the station! Only the "To-From" indicator changes.

In the same example, if your aircraft is on a magnetic heading of 120°, but 300° had been set on the radial selector, the course indicator needle would be pointing to the right as shown in C and D. You would, however, still have to correct to the left to get onto the desired radial. This is referred to as a reverse indication. However, if you mentally turn the aircraft around and fly from right to left on a heading of 300°, it is seen that the course needle indicators, with a 300° radial selected, point to the right. You would correct to the right to get onto the desired radial.

The practice maneuvers that follow will provide ample opportunity to practice interpreting VOR indications.

ORIENTATION

Assume that the aircraft's position with respect to the station is unknown (or lost). It is necessary to "orient" yourself with respect to the station. The first step after tuning to the radio station is to make a positive identification of the station. Listen to the Morse code or to spoken identification to be sure you have the desired station tuned in. In fact, *you should never use a radio station for any navigational purpose unless a positive identification is made.*

Then rotate the radial selector until the course indicator needle centers. Read the "To-From" indicator. The radial selector will give you a magnetic direction with respect to the station for the LOP and the "To-From" indicator will tell you on which side of the station you are located. Remember that the radial selector has no relationship to the magnetic heading of the aircraft.

With the information you have just obtained, you can determine the heading necessary to fly to the station. No information is known or can be assumed about your distance from the station.

INTERCEPTING AN AIRWAY

To intercept an airway, first place the airway heading on the radial selector and determine whether the course needle swings to the left or right. Then turn the aircraft to a magnetic heading that will intercept the airway at an angle of 45°. If the course needle is to the left, subtract 45° from the airway heading; if the needle is to the right, add 45° to the airway heading.

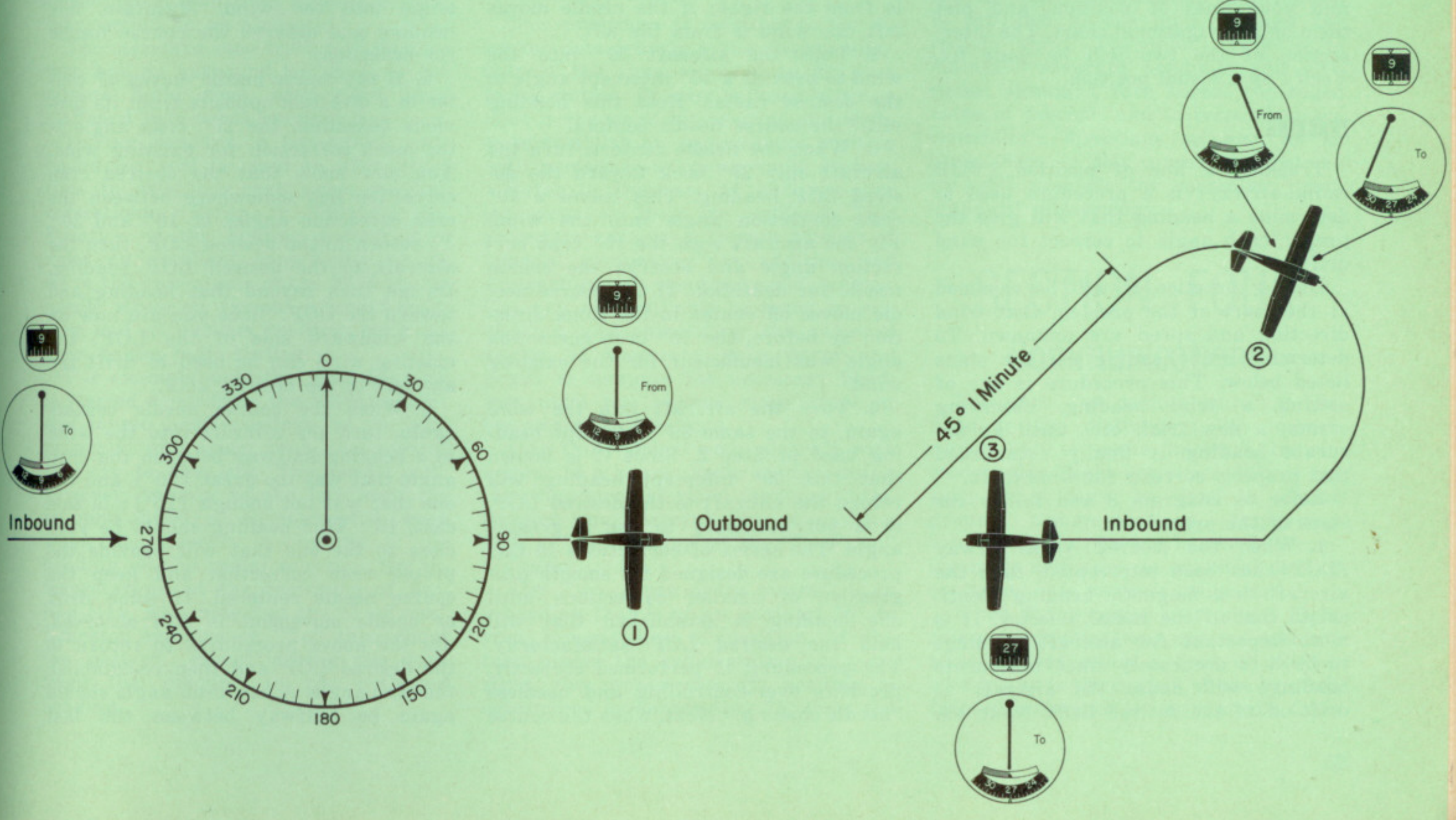
Remain on this intercept heading until the airway (LOP) is reached. To avoid overshooting the airway, the turn to desired airway heading should be started when the course needle has reached a deflection of about ⅛ its travel off center.

FIXING AN AIRCRAFT'S POSITION

A fix is a positive determination of an aircraft's geographical position. In radio navigation a fix can be obtained three ways as discussed in "Types of Navigational Systems."

DIAGRAM 10. Procedure Turn

1. Aircraft has passed the VOR and proceeds on the outbound LOP with a "FROM" on the "TO-FROM" indicator for 2 minutes.
2. Turn left 45° and fly for 1 minute. Then begin a 180° standard rate turn to the right. Reset the course selector to inbound LOP.
3. Intercept the inbound LOP and correct for drift inbound to the VOR. "TO" is indicated on the "TO-FROM" indicator.



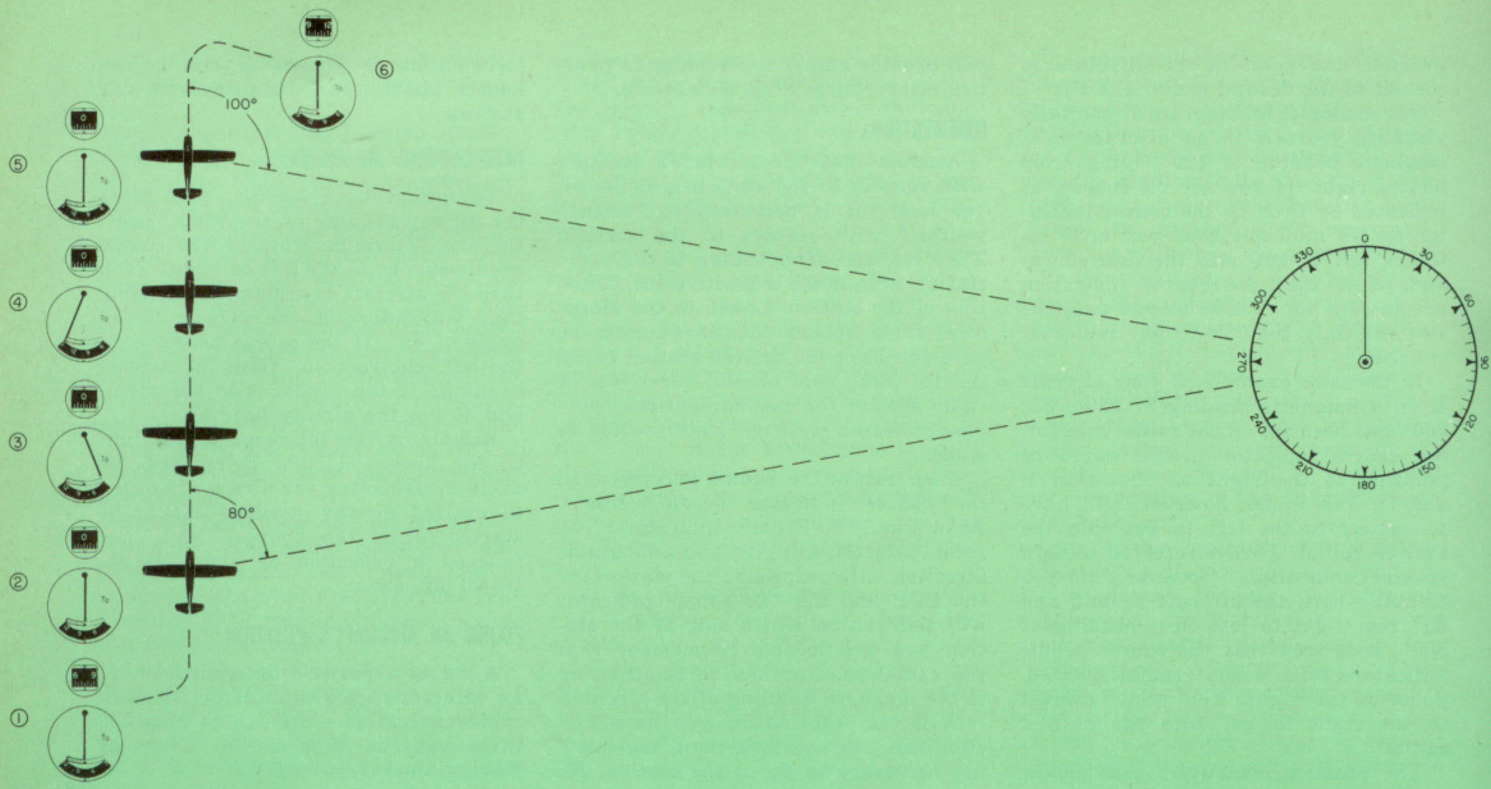


DIAGRAM 11. Time Distance to a Station

1. Inbound aircraft begins turn to place station 080° relative to the nose of the aircraft.
2. Pilot notes time as the course needle centers on the line of position at an angle of 80° to the aircraft's nose.
3. Course needle moves well off center.
4. Pilot adjusts the radial selector by 20° so the course needle swings through center to the other side.
5. Course needle centers on the new LOP. Pilot notes time, and determines time between lines of position in minutes and seconds. Multiply time between LOPs by three, for time to the station.

$$\text{Minutes to station} = \frac{60 \text{ X minutes flown}}{\text{degrees of bearing change}} = \frac{60 \text{ X minutes flown}}{20^\circ} = 3 \text{ X minutes flown}$$

6. Turn to station and correct for wind drift inbound to the station.

In practice, you will orient yourself to two navigational stations as described in the orienting procedures, find your lines of position, and plot them on a navigational chart. The intersection of the two will be your fix. Verify by a visual position.

TRACKING

Tracking a line of position (VOR radial-airway) is a procedure used to determine a heading that will give the proper crab angle to correct for wind drift.

During practice, it will be assumed at the start of the problem that wind direction and speed are unknown. To determine crab heading use the steps listed below. This procedure is one of setting a trial heading, observing errors, a new trial, etc., until an accurate heading is finally established that properly corrects for wind drift.

Refer to Diagram 8 and follow the steps of the procedure:

1. When the desired VOR airway (LOP) has been intercepted, turn the aircraft to a magnetic heading identical to that of the radial selector. It is most important for aircraft headings to be held accurately since inaccurate headings will cause the aircraft to drift off of the desired LOP. Next, observe the course needle for any displacement from the center position. If the needle moves to the right, the wind is from the right; if the needle moves left, the wind is from the left.

2. Turn the aircraft 30° into the wind to provide a 30° intercept angle to the desired radial. Hold this heading until the course needle centers.

3. When the needle centers, turn the aircraft only 20° back toward the desired LOP heading. This leaves a 10° crab correction angle into the wind. Fly the aircraft with the 10° crab correction angle and observe the course needle for deflection. If the course needle moves off center in the same direction as before, the 10° crab correction angle was insufficient for the existing wind.

4. Turn the aircraft into the wind again, to the same 30° intercept heading used in Step 2. Since it is known that this 30° intercept heading will return the aircraft to the desired LOP, it is not necessary to use a greater angle. The series of corrections in this procedure are designed for smooth progression of smaller corrections until one heading is established that will hold the desired LOP satisfactorily. The procedure, if performed correctly, prevents over-controlling and needless "needle chasing." Next, when the course needle centers, turn the aircraft only 10° toward the desired LOP heading. This now leaves a 20° crab correction angle into the wind. Maintain this heading and observe the course needle for deflection.

5. If the course needle moves off center in a direction opposite from its previous deflection, the 20° crab angle is too much correction for existing wind. You now know that the desired crab correction lies somewhere between the crab correction angles of 10° and 20°. To return to the desired LOP, turn the aircraft to the desired LOP heading. Do not turn beyond that heading and toward the LOP. Since you are now on the windward side of the LOP, the existing wind can be used to drift the aircraft to the desired LOP.

6. When the course needle centers again, turn the aircraft into the wind to a heading halfway between the crab angle that was too great (20°) and the one that was not enough (10°); in this case, 15°. This heading should be very close to the one that will provide the proper crab correction and keep the course needle centered. If some drift or needle movement is still observed, use the above procedures to return to the desired LOP and then re-establish the crab angle. A new crab angle should again be halfway between the last

angle that provided too much correction and the last angle that was not sufficient, or in this case, about 2° correction. Once this crab correction heading is established, small additional adjustments to maintain the needle in the center position should not exceed 5°.

For a rule of thumb, the following table lists the approximate degrees of crab correction necessary to compensate for a 90° crosswind component equal to a percentage of the aircraft's true airspeed:

Crosswind equal to	*Crab angle required*
1/2 true airspeed	30°
1/4 true airspeed	20°
1/6 true airspeed	10°

IDENTIFYING STATION PASSAGE

Identification of passing over a radio station is one of the methods for positive identification of a fix. With VOR radios, station passage will be indicated when the course needle swings rapidly from side to side a few times. At the same time the "To-From" indicator will switch back and forth and finally change from its prior reading.

HOLDING PROCEDURE

Holding procedures are used to maintain an aircraft in position over a fixed geographical area. Holding is necessary in air traffic control to provide proper separation with other aircraft so you can proceed safely and wait for a landing sequence when traffic is heavy in a terminal area.

The holding pattern is always oriented around a radio fix. It is a race track pattern, with the inbound leg terminating at the specified radio fix. The turn to the outbound leg is begun as soon as the fix is passed. The specified fix can be a radio station or at the intersection of two lines of position (an intersection on an airway).

The standard race track holding pattern has an outbound leg equal to one minute flight time, with right hand standard rate turns between legs.

During practice, a two-minute outbound leg will be used to allow more time to establish crab angle heading corrections (Refer to Diagram 9). Practice of the holding pattern provides an excellent opportunity to observe the indications of the VOR course needle while on various aircraft headings and at various positions with respect to the radio station.

For example, note that once the turn is started away from the inbound LOP, the course needle swings to the left, properly indicating that the desired LOP is to the left. The needle will, however, remain to the left until the inbound LOP is re-intercepted, even when the aircraft is opposite to the heading on the radial selector (See interpretations at the beginning of Section III). Also note that the "To-From" indicator remains on "To" throughout the pattern, except during the turn from the inbound to the outbound heading.

PROCEDURE TURN

The procedure turn is normally used to reverse course after passing a radio station so that you can approach the radio station on a predetermined LOP.

The predetermined LOP, combined with flying at certain altitudes, is used to place the aircraft into position for the final approach and let-down phase of an instrument approach to an airport. It is, therefore, a part of every standard instrument approach procedure. It is also a procedure that can be used by VFR pilots for an orderly method to reverse course if you inadvertently find yourself in a critical visibility situation. It can be used to maintain a definite orientation to a radio station or an airport, when approaching an uncontrolled airport or one that is hard to locate visually.

Referring to Diagram 10, note the time passing the station and use the tracking techniques to establish wind correction angles on the outbound LOP. Two minutes after passing the radio station turn the aircraft 45° to the left of the outbound LOP. Use standard rate turns. Note the time rolling out on the new heading and hold for one minute.

When the left turn is started, the course needle will swing to the right. After one minute, begin a 180° standard rate turn to the right. During the right turn, the radial selector is adjusted to the inbound LOP heading. The heading at the completion of the 180° turn will place the aircraft to the right of the inbound LOP and on a 45° intercept angle with the course needle to the left. Execute a normal intercept to the inbound LOP, track for wind corrections, and descend 500 feet at a standard rate while proceeding to the station.

TIME-DISTANCE CHECK

This procedure is valuable to the pilot for determining a close approximation of the time required to fly to a radio station. It can be used when a pilot is unsure of his position and wishes to establish an approximate position with respect to a known radio station.

Refer to Diagram 11 and visualize the steps as they are outlined. This procedure requires a certain amount of "mental gymnastics" in addition and subtraction of headings and angles. Use any aid available to assist in visualizing and calculating the required angles. If necessary, take paper and pencil to compute the necessary headings until you become more adept at the mental calculations.

Step One—Orient your aircraft with respect to a known radio station, using the procedure described previously. Determine your present line of position with a "To" reading on the "To-From" indicator.

Step Two—Turn so the aircraft is on a heading that is at an angle of 75° to your present line of position. If the turn places the radio station on your right, the proper aircraft heading is determined by subtracting 75° from the heading on your radial selector. Add 75° if the station is on your left. As you proceed on this new heading, the angle between the aircraft's nose (heading) and your line of position will increase. The time required to fly between the LOP's that make an angle of 80° and 100° to the aircraft's nose is the figure used to calculate the approximate time to fly to the station.

Note: The initial turn to a 75° angle allows a 5° lead which is used up in turning and the time to establish the new heading. As the aircraft begins the turn to the new heading, the course needle will swing to one side. At the completion of the turn, reset the radial selector by 5° so the course needle moves to the opposite side. This sets the radial that will make an angle of 80° to the nose.

Step Three—Note the clock time in minutes and seconds as the course needle centers. As the aircraft proceeds, the course needle will swing to one side. Reset the radial selector by 20° so that the course needle moves to the opposite side. If the station is on the right, add 20°; if the station is on the left, subtract 20°.

Step Four—Note the clock time as the course needle centers and compute the elapsed time in minutes and seconds between clock readings.

Step Five—The time to the station is equal to the elapsed time in minutes and seconds, multiplied by three (Refer to Diagram 11 for formula). Turning to the station, allow 5° for line of position change during the turn. Use tracking techniques for wind drift correction inbound to the station.

GROUND-CONTROL APPROACH

Ground-controlled radar approaches are made using the standard flight maneuvers and speeds practiced in this course. All navigational information is provided to the pilot through the spoken word. The pilot's task is to maintain accurate headings and altitudes, standard rate turns, controlled rates of descent, and to respond to the controller's directions as soon as he gives them. In this course, the instructor will simulate the controller using standard phraseology.

SECTION FOUR

Communications

The verb "to communicate" is defined in the dictionary: "to impart, convey, or to make known." In our modern-day flight activities, this is exactly what must be done in air to ground communications. Imparting, conveying, and making known is becoming more and more an essential part of continued safe aircraft utilization.

When flying under instrument flight rules, communications are an absolute necessity—as much a part of the pilot's job as is the control of the aircraft through reference to instruments. Communications are necessary when operating from a controlled field to "impart or convey" instructions.

Only through communications can two of the navigational aids be obtained —ground radar and direction finding. Communications from FAA facilities can increase the safety level of flights under visual flight rules when they "make known" late weather conditions, changes to radio facilities en route, or the status of airports at terminal areas. For the pilot who "makes known" emergencies or potential critical situations it may mean the difference between a successful and disastrous completion of a flight.

To assist the pilot and guide the safe, smooth flow of aircraft traffic, the FAA has established a large network of communication facilities throughout the United States. The pilot flying under instrument flight rules must understand this network. The pilot flying under visual flight rules can benefit greatly by adding a new dimension of safety to his flights if he knows what this network can provide.

This section will discuss, in general, all of the FAA communication facilities. No attempt will be made to discuss all of the things each facility can provide, but rather it is intended to provide a general understanding of their functions and relationship. It will show how this network can provide the pilot on visual flight rules with most valuable assistance.

The entire FAA communications network is separated into three general categories which are commonly identified by their primary functions. These are:

1. *Air Route Traffic Control Centers* —These are commonly referred to as the "center" or "ARTC." Its function is to provide air traffic control to flights under instrument flight rules operating within controlled airspace. An ARTC is primarily concerned with the en route phase of a flight.

Only 28 ARTC Centers cover the entire United States; consequently, each one is responsible for a large geographical area. Large sections of each area can be out of range of the radios placed at a Center location. Therefore, radio transmitters and radar antennas are placed at sites far removed from the actual Center location. With these remote sites, the center can have continuous and direct communications with pilots over all segments. Communications with the center are accomplished through the VHF radio between 118.2 mc and 135.9 mc.

2. *Flight Service Stations (FSS)*— This facility exists to provide just what its name says—service. The FSS personnel are housed on an airport and are trained to provide pre-flight planning services prior to a flight and in-flight services while en route. The services include reported weather conditions, forecasts, notices of radio aids that are inoperative, and hazards to flight.

To the pilot on cross-country under visual flight rules an important service is that of accepting your flight plan and relaying your expected arrival time to the FSS at your destination. This flight plan system insures search and rescue activities if you fail to arrive at your destination. The system provides even greater protection to the pilot when "flight following service" is requested. In "flight following," selected flight service stations along your route are notified of your flight. These en route flight service stations prepare information for your particular flight on weather, radio aids, and hazards to flight. As you approach the en route FSS, the information will be relayed to you. If the FSS cannot establish contact with you, search and rescue activities will be initiated, rather than waiting for your arrival station to initiate a search as done under a previous system. Since this service can provide a significant increase in the safety of your flight, it is strongly urged that a flight plan be filed on *every* cross-country flight.

FSS personnel are trained to be completely familiar with detailed terrain features in their surrounding area. This is valuable to the pilot who is lost or disoriented. If the pilot can describe what he sees on the ground, the FSS personnel can help him locate his position. There are 432 FSS's located at selected airports throughout the United States. Each FSS may be received through selected navigational aids in its area. But all of them have in common two frequencies on which they can be heard—122.2 mc and 126.7 mc. All FSS's also have in common two frequencies that they listen to—122.1 mc and 126.7 mc. All FSS can also listen and talk on emergency frequency—121.5 mc.

3. *Airport Traffic Control Tower*— This is a misleading name in some respects since "the tower" can actually consist of four different units. It would be best for your understanding to think of the whole Airport Traffic Control Tower as serving all the needs of a terminal area. Then it must be understood that all aircraft landing, taking off, or operating on and around the airport served by the Airport Traffic Control Tower must maintain two-way communications and operate in accordance with the clearances the tower issues. Your two-way communications will be maintained with one of the four units that follow.

a. *Local Control,* or what you normally refer to as "the tower," is primarily concerned with takeoffs and landings, the traffic pattern, and general VFR operations of all aircraft in the airport traffic area. The local controller is stationed in the glass cab on top of the tower structure so he has a good view of the airport and surrounding airspace.

At each tower facility there is one frequency normally used to talk and listen to the local controller—between 118.1 mc and 135.9 mc. You can also talk to most local controllers on 122.5 mc, but in areas where two or more towers are close together you may have to talk to the local controller on 122.6 mc or 122.7 mc.

Direction finding equipment is usually located in the glass cab near the local controller.

b. A *Ground Control* facility is located at every tower facility. The ground controller's primary function is to control the movement of all traffic on the ground at the airport. Communications with this facility for ground traffic allows the primary tower frequency to be used for airborne traffic operations. The ground controller will listen and talk on a frequency of 121.7 mc or 121.9 mc, depending upon which is installed at the airport. It is not mandatory to use this facility. If you do not have the frequency installed in your aircraft and the local controller requests that you switch to ground control, just say, "unable," and remain on local control frequency.

The ground controller is stationed in the tower glass cab next to the local controller.

c. An *Approach Control* service may be designated at an airport Traffic Control Tower, if local traffic warrants, to control aircraft arriving, departing, or operating in the vicinity of the airport under instrument flight rules. Approach Control will normally begin control of an IFR aircraft after Air Route Traffic Control Center has guided it to the terminal area served by the Airport Traffic Control Tower. The control of an IFR aircraft is usually transferred to Approach Control at a radio fix within a 30-mile radius of the airport. Many of the Approach Control facilities use radar for more efficient traffic flow in the terminal areas. This radar can also be used for ground-controlled approaches.

The personnel in Approach Control are not normally located in the tower cab. They are usually located in a separate room in close proximity to the Local Control personnel. Approach Control usually has one frequency (different than the local controller's) on which you can talk and listen to them. However, their radio systems are usually designed so the local controller can talk and listen on the Approach Control frequency from his station. The reverse is also true so that approach controllers can talk and listen on local controller frequencies. At airports with a large amount of inbound IFR traffic, two frequencies may be assigned to Approach Control, one for traffic approaching from one direction and one for the other.

d. *Departure Control* may also be designated at an Airport Traffic Control Tower if the total amount of arriving and departing instrument flight rule traffic could overload the Approach Control frequency and personnel. Departure Control will then handle the departing traffic.

The departure controller is located in the same room and usually sits next to the approach controller. Normally if the approach controller has radar, the departure controller has an identical radar set. Departure Control will be assigned a separate frequency on which to listen and talk on, but are again hooked up to allow listening and talking on both Approach and Local control frequencies. The reverse is again true.

This brief description has pointed out the primary use of each facility. There is one additional relationship between all of the facilities that is very important for the pilot to understand. This is the way in which all communications functions tie together for their inter-communications, which is:

1. All Airport Traffic Control Towers have direct communications with the Center in which they are located.
2. All Flight Service Stations have direct communications with their Center.
3. All centers have direct communications with each adjacent Center.

This means that any FAA communications facility can, through some 350,000 miles of wires and cables, relay a message to any other FAA communications facility in the entire network.

This is a significant tie-in when a pilot has an emergency because the FAA communications network has additional instructions when an emergency exists. These instructions are that the center shall be informed of an emergency and they shall provide all available assistance and enlist all other available services that may help.

To the pilot in an emergency situation, the FAA will put at his disposal all of the capabilities of their network. Under this system, the services of FAA facilities at distances exceeding the range of your transmitter can be called upon to provide assistance. For example, a pilot lost at night with minimum visibility contacted an FSS. The FSS personnel obtained the services of a center's remote site radar to direct the pilot to an airport terminal area. Then Approach Control radar directed him to the airport. In this case three facilities were used, yet the pilot received all instructions directly from the FSS.

In an emergency, avail yourself of everything in the area that can be of help to you. The only thing you have to remember is to "get on the air" and tell anyone in the FAA network of your needs. They are trained to handle emergencies and will provide anything within their control to assist you.

USING FAA COMMUNICATIONS FACILITIES: FSS

In routine flying, under visual flight rules, the FSS is the facility you will communicate with most frequently. FSS personnel take the "service" in their name to heart. They are most helpful in obtaining any information needed to make your flight safer. They will take position reports and provide weather reports and forecasts, and give you the frequencies for towers, approach control, departure control, radar, and D/F services. They provide notices of hazards to flight and help you in an emergency. In short, if you are in need of any in-flight assistance, call the nearest FSS.

TOWERS

The tower (or local controller and ground controller) will be the next most used facility. They are interested in maintaining a safe, expeditious, and efficient flow of traffic on and around the airport. This efficiency can, however, create problems for the transient or relatively inexperienced pilot. The controller, when traffic is heavy, may give instructions too quickly to be completely understood by pilots unfamiliar with the airport or unfamiliar with operating with a control tower. In circumstances where instructions are not received or understood, continuing to fly into the traffic pattern can cause delays in traffic handling or cause unnecessary embarrassment.

One way to avoid this kind of situation is to tune in to the tower frequency several minutes before you reach the airport and listen to the communications with other aircraft. You can learn the instructions the controller is issuing before you are ready to call. Since this technique cannot be used in every situation there are two phrases that you should have in your vocabulary.

The first is, "say again." This simply means that you didn't understand or receive the message that was sent, so please repeat. Any time you don't understand, use it; they will gladly repeat. There should be no embarrassment in using this phrase. But, you can cause problems if you acknowledge instructions and do not carry them out because you didn't understand.

The second phrase is, "I'm unfamiliar with this area (or airport)." If a traffic controller has given you a landmark or check point with which you are unfamiliar, say so. It merely lets the controller know he has to provide instructions that are more meaningful to you.

These are really just examples of the word "communications" in action; "making known" and "imparting" information that is understood by both parties.

OTHER

The communications functions other than FSS and tower were described as being available primarily to handle flights under instrument flight rules. However, this does not mean they are restricted absolutely to IFR communications. In fact, one of these facilities can be used very beneficially by a pilot flying under visual flight rules. This facility is Approach Control Radar. In a terminal area, if you request VFR traffic advisories, Approach Control Radar will usually be able to serve you. They will positively identify your aircraft on their radar scope. The radar controllers advise you of any aircraft on their scope that will pass within three miles of your position—most helpful in minimum VFR visibilities. You are, of course, obligated to remain under visual flight rules. You cannot assume that you can fly through a cloud because you are on the radar scope. They are advisory only.

You must also remember that they are primarily for IFR traffic. If IFR traffic is heavy, they may not be able to serve you. However, if this is so they will tell you. But, if time and traffic will allow, they can provide other services such as advisories on the location of local thunderstorms and practice ground-controlled approaches.

Approach controllers need to perform a certain number of ground-controlled approaches in order to stay proficient. It is recommended that you call Approach Control on a good VFR day, explain you are a VFR pilot, and ask for familiarization with GCA. If traffic allows, they will be pleased to give you the practice. This serves a twofold purpose. It gives the controllers needed practice and it gives you the opportunity to become familiar with GCA services, a life saving procedure that can be used in emergencies. (This also holds true in requesting practice on the use of direction finding steers.)

The best way to learn more about a facility is to use it. It is most highly recommended that both radar and direction finding be practiced on your next two flights to tower controlled facilities. It is also suggested that you visit a tower and explain that you would like to become more familiar with its operation. You can be assured of a very enlightening tour and that you will leave with a greater depth of understanding of how they can serve you.

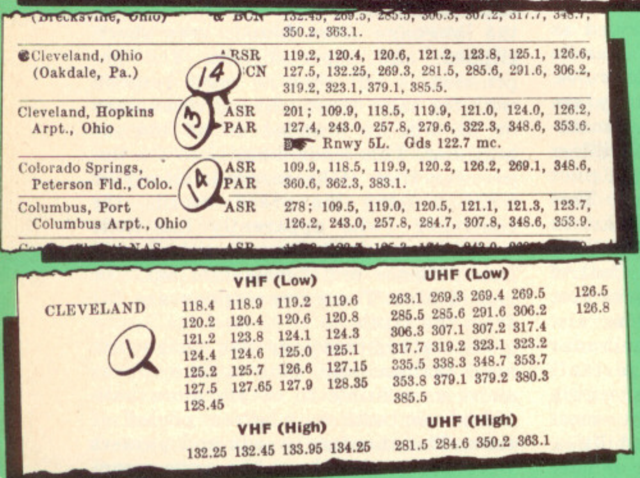
TIPS ON COMMUNICATIONS

Nearly everyone has "mike fright" when first using the microphone. This comes from being unsure of what you want to say or how to say it and the awkward feeling of having an audience. There is only one way to get over mike fright and that is to use the microphone. Until you are more at ease with the phraseology, practice saying to yourself just exactly what you want to say into the mike. Then pick up the mike and say it.

The use of "proper phraseology" sometimes becomes a stumbling block at the same time a pilot is experiencing mike fright. To the person who is inexperienced in aircraft communications, the language often sounds very short, clipped, and super-efficient. The impression is left that he must respond with the same short, clipped vocabulary or he will be branded as an obvious beginner. This leads directly to the impression that, if he responds slowly or without using the proper words, the controller (who apparently has little time because he talks so quickly) will lose patience and "chew him out," or report him. These impressions are far from the truth.

Aircraft phraseology was designed to keep transmission time on the air as short as possible to obtain more individual contacts in a given period of time. The standard words and phrases were designed to have the same meaning to all pilots. These are worthy goals. Like any new vocabulary, however, it takes time to learn and use properly.

DIAGRAM 12A. The Airman's Guide. At the bottom right hand corner is the key to the comparison of sources of information. (Also see Diagrams 12B and 12C.)



FREQUENCIES LISTED ACCORDING TO PUBLICATION

		Airmens Guide	Sectional Chart	Enroute Chart
1.	Center	Yes	No	No
2.	Flight Service Station	Yes	Some Receiving No Transmitting	Some Receiving Some Transmitting
3.	Tower (Primary)	Not Directly	Yes	Yes
4.	Ground Control	Yes	No	Yes
5.	Approach Control	Not Directly	No	Yes
6.	Departure Control	Not Directly	No	Yes
7.	VOR	Yes	Yes	Yes
8.	Homer	Yes	Yes	Yes
9.	L. F. Range	Yes	Yes	Yes
10.	DME	Not Directly	Some Stations, Yes, Others Indirectly	Some Stations, Yes, Others Indirectly
11a.	ILS Localizer	Yes	Existence of Facility Only	Some Only
b.	ILS Glide Slope	Yes	No	No
c.	ILS Outer Marker	Yes	No	Some Only
12.	Marker Beacon	Yes	Yes	Yes
13.	Precision Approach Radar	Yes	Yes (GCA)	Existence of Facility Only
14.	Surveillance Approach Radar	Yes	No	Existence of Facility Only
15.	Direction Finding	Yes	Existence of Facility Only	No

Direct Identification of Nav/Com Frequencies

Even the controllers and "pros" were hesitant when they started.

To communicate is important; whether you use the so-called "proper phraseology" is of little importance. Ask a controller on your next visit to the tower. He will tell you, "How you say it matters none. If you can't remember the proper phrase, don't worry. Say what you want the best way you can, in just plain old English." He will also add enthusiastically, "Just be sure to call!"

SECTION FIVE

Sources of NAV/COM Frequency Information

For maximum safety in flight, the pilot should have a source of information that provides immediate access to the geographic location and frequency of all the nav/com facilities discussed in previous sections.

With this in hand, he could determine which navigational aids and communications facilities were available as he progressed on a flight. In the event of unexpected weather or other emergency situations, this would allow the pilot to know immediately which nav/com facilities could be used for any needed assistance. During routine flights, by knowing and using the nav/com facilities available, the pilot could gain valuable understanding and practice which would better prepare him for instrument training.

It would be ideal to have one chart that would provide all this nav/com information, be easily read, and complete with both terrain and airway information. But this kind of chart is imaginary; it does not exist. To gather the information on all existing nav/com facilities means to search through two or more charts and tables; charts that have good terrain features but are weak in nav/com frequencies; charts that have excellent nav/com frequency and airway listings but no terrain features; or tables of nav/com frequencies but no terrain or airway information.

Within the confines of lightplane cockpits, a search for information from two or more charts and tables is difficult. Use one hand to fly, and the other to handle charts and tables and divide your attention between searching looks outside the cockpit and glances at the charts. You are busy. You must do this today, but you can make your job in the cockpit easier by thoroughly familiarizing yourself with the available charts and tables, and by preflight planning.

To provide the pilot with the information necessary for a flight, several types of charts and tables have been prepared by Government and commercial publishers. Many of these contain the same information but present it in slightly different ways. Some are more easily used and understood than others. Some will emphasize information needed during certain phases of flight. Therefore, the charts or tables a pilot decides to use must be selected for his individual needs.

It is strongly suggested that each pilot review the material published and determine those publications that provide the information he needs in a manner that he finds easy to use.

Figure 12 (A, B and C) compares the three ways the Government publishes nav/com information. First, in table form—the "Airman's Guide"; second, the Sectional Chart, used primarily for VFR flights; and third, the Low Altitude Enroute Chart, used primarily for IFR flying.

In Figures 12A, 12B, and 12C all navaids and communications facilities discussed previously are noted on extracts from the three publications. The index numbers provide a reference to the nav/com facilities on each publication. There are other differences between them, too numerous to list and some obvious and some less obvious.

Regardless of which chart or table is selected, however, the pilot will find certain symbols or code letters used to designate information that appears repeatedly. The pilot must study these codes so that he can readily obtain the information that is provided. It is most important that the pilot be familiar with *all* information available in a publication as well as that which is not included.

In using Government publications for the examples there is no intent to slight other excellent publications. Space will not allow a complete comparison of all published charts and tables.

The Airman's Guide is used because it is a common reference for Notices to Airmen (NOTAM's) and other special information the FAA wishes to publicize to the airman public. The Sectional Chart is used because it is the terrain chart most familiar to the majority of pilots, and the Geodetic Survey Low Altitude Enroute chart is used only as a representative type of chart.

Pilots are again urged to select the publication that presents information to suit their needs.

The following will point out some of the strengths and weaknesses of the presentation of nav/com information.

AIRMAN'S GUIDE

The prime advantage of the Airman's Guide is that it carries a complete list of all frequencies used to transmit to all communications facilities, as well as the frequency to receive all navigational aids. This listing is revised every two weeks so it is a very reliable source for the current frequencies in use.

The Airman's Guide, however, has some features that prevent it from being used to the fullest advantage. For example, the frequencies for an Airport Traffic Control Tower—that is local, approach and departure control—are listed in numerical sequence without regard for assignment. All of the necessary frequencies are included but the numerical sequence means you cannot pick out the one frequency primarily used by the local controller.

In another case, the frequencies used to communicate with FSS are not shown following a VOR frequency listing even though you can use the VOR to listen to them. If a low frequency homer or range with voice facilities is located in the same terminal area, the frequencies for communications with the FSS will be listed following the Low Frequency tabulation.

The Airman's Guide also lists complete information on all parts of the ILS system including localizer, glide slope, inner and outer marker frequencies. For radar facilities it denotes geographic location and whether it is used for precision (PAR) or surveillance (ASR) approaches or for center en route control located at a remote site. However, ILS and radar information are listed in different sections and are separate from all other nav/com frequency listings.

The disadvantages of the Airman's Guide are: first, frequencies used to communicate with some facilities cannot readily be determined; second, information pertaining to a terminal area is spread out over several different sections.

It should be noted that the FAA has recognized deficiencies in the presentation of information in the Airman's Guide and Flight Information Manual. They are presently working on a revision that will put the information in a more useable form. Their new format is expected to be published during 1964.

SECTIONAL CHART

The Sectional Chart is a necessity in a pilot's kit because it contains detailed terrain features, and the location of all airports. A current Sectional can be used reliably for navigation by pilotage.

Frequencies for nav/com facilities are often revised several weeks before the normal six-month revision schedule for a Sectional Chart. This means all frequencies on the chart must be checked against a current listing before they can be considered reliable for use. The FAA uses the Airman's Guide and NOTAM system to notify the airman public of changes in information on Sectionals.

Frequency information printed on the Sectional Chart is limited since it was originally designed for "contact" flying. In general, all the VOR, low frequency homers, and ranges used for en route navigation are positioned geographically. These aids are shown with the frequency you must have to receive the station. Code letters are used to denote the availability of distance measuring equipment, instrument landing system, direction finding equipment, and precision approach radar. It should be noted that a station with surveillance radar will be indicated on the chart as though it had no radar.

Communication frequencies for Airport Traffic Control Towers are limited to the one frequency used to listen and talk to the local controller. A second

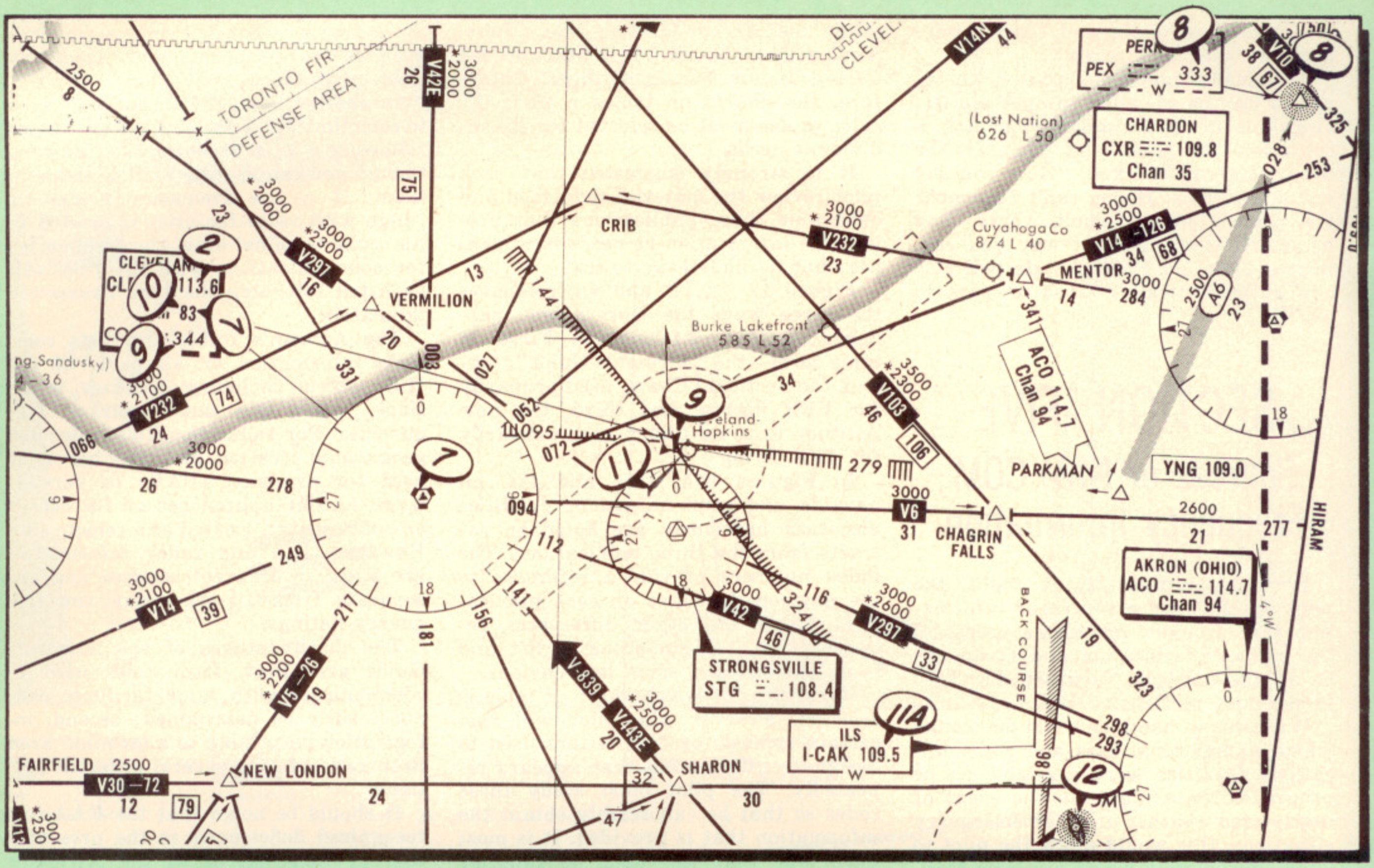


DIAGRAM 12C. Enroute Low Altitude Chart—U.S. For use up to but not including 14,500 MSL. Key to the numbered items in this chart and in Diagram 12B will be found on page 76, showing how same information is provided in three forms

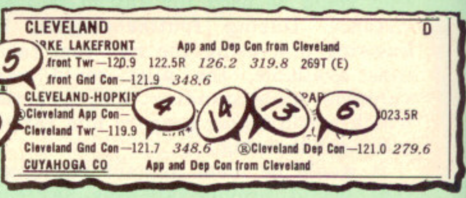
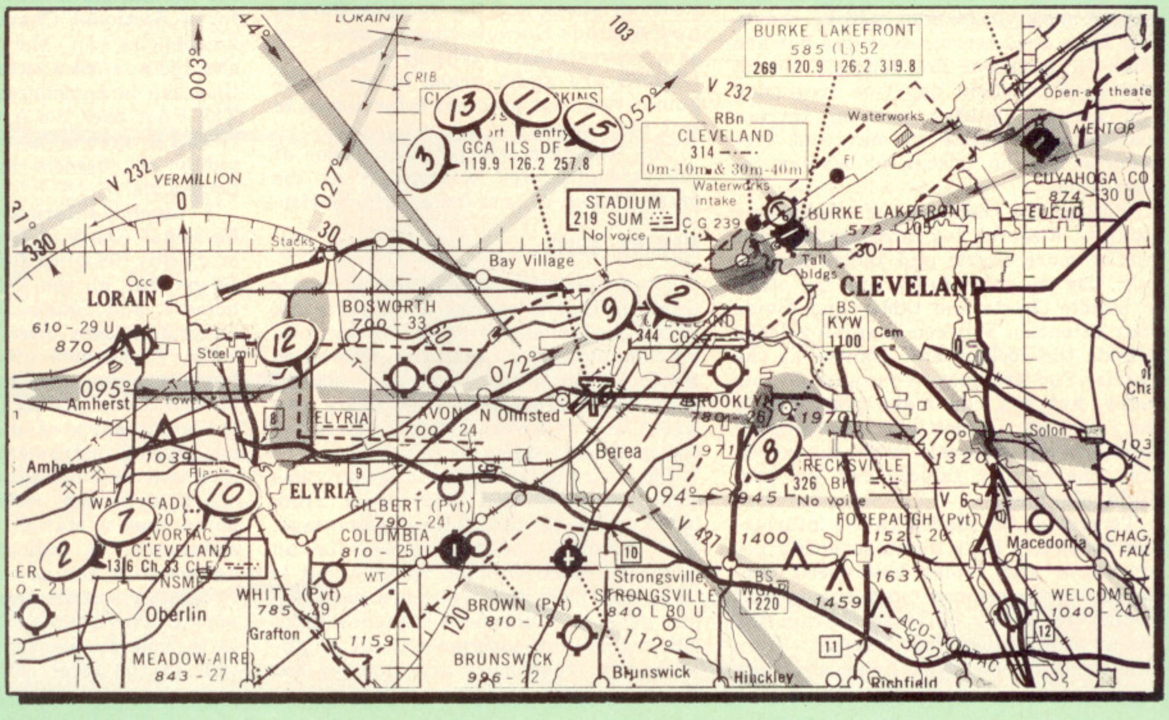


DIAGRAM 12B. Cleveland Sectional Aeronautical Chart



frequency is sometimes shown if the tower cannot listen to you on the "common tower" frequency. No information is shown for departure, approach, and ground control. For FSS communications, a "no voice" notation is made on the navigational aid if you cannot listen to them on that navigational aid. No information is given on other frequencies available to talk or listen to FSS.

The outlines of controlled airspace segments such as airways and control zones are also shown.

The Sectional Chart is used to effectively locate principal navigational aids available on a particular flight path. Another source of information must be referred to, however, for verification of nav frequencies, and those frequencies used to communicate with the various communications facilities.

The second source must also be referred to if a pilot wishes to use *all* aids available on his flight. For efficiency, he will find it helpful to memorize the frequencies common to Flight Service Stations and most towers. When a search for the frequency of aids not shown on the chart would demand too much time with your "head in the cockpit," or if the second source is not available, call the Flight Service Station. They will provide the information you need.

LOW ALTITUDE ENROUTE CHART (Geodetic Survey)

This chart is designed primarily for flying under Instrument Flight Rules. Since Instrument Flight Rule navigation can be accomplished exclusively by radio navigational aids, and since control of traffic is maintained through two-way radio communications, frequency information on the Enroute Chart must be accurate and up-to-date. These charts are revised every four weeks.

VOR and low frequency information is presented in ways similar to those used on the Sectional Charts. Code letters are again used to denote distance measuring equipment. Availability of direction finding equipment is not shown, while ILS localizer courses are placed on the chart but only certain ones list the frequency.

This type of chart actually comes closer to providing the pilot with complete information on all the nav/com facilities discussed, and in an easily used form. Looking at Diagram 12C, you will note that on the table, frequencies used to communicate with all parts of the Air Traffic Control Tower are clearly listed. Frequency information can be easily and readily located by the pilot. Also, an "R" with a circle around it, quickly indicates that radar (precision or surveillance approach) is available at that communications facility.

The frequency listing for communications with the FSS are not so complete and direct, but at least some frequencies are listed.

Another asset of this type of chart is the airway information. Listings of distances between radio fixes and magnetic headings of airways eliminate awkward plotter work in the cockpit. Notations of minimum safe en route altitudes immediately provide the pilot with a safe altitude to clear terrain and other obstacles.

The VFR pilot who flies cross-country extensively may find this type of chart a valuable supplement because more nav/com information is easily and directly obtained. But the chart can only be a supplement to other information due to the lack of terrain information, complete listing of airports, and NOTAM's.

The above discussion has viewed certain publications from a standpoint of ease, directness, and clarity with which nav/com frequencies may be obtained. No attempt was made to evaluate all features of each chart. One thing should have been readily apparent: to secure the maximum information from any chart or table, the pilot must study the symbols and codes so he is completely familiar with *all* information available.

No attempt is made to recommend the particular chart or table to be carried. It is recommended that you review all the publications on the market. Select the ones that are easily used and present the information that suits your individual needs. Then use the publications and the nav/com aids available to you.

SECTION SIX

Summary

As at the completion of the AOPA 360° Rating Course, the knowledge and skill you have gained in this course entitle you to no new pilot privileges. The FAA's regulations on weather minimums for Visual Flight Rules still apply and your new knowledge and skill can not be used to push through weather. But, as was determined in the 360° Rating Course, your new capabilities can assist you if you encounter an unexpected weather emergency.

Applications of what you have gained from this course also reach in other directions. You have increased your capabilities to extricate yourself from a weather emergency, but this is only one of three goals of this course.

It is intended that through this training you will have a greater insight in preventing emergencies through increased use of the FAA navigation and communications systems. It is intended that you develop the capability to control your geographic position precisely and that you will obtain more information for the safe conduct of your flight. Through planned use of your nav/com systems you can prevent lost aircraft incidents and emergencies caused by sudden encounters with unknown weather. In working to eliminate *potential* accidents you have "pulled your own bootstraps" to make your flying safer.

During this course, you have practiced some of the procedures used in actual cross-country instrument flying. This is a significant step and is the third goal of this course. This goal is directed at the pilots who began the course saying, "I should probably go get an instrument rating"; at pilots who have had the feeling that instrument flying is exclusively for the "pros"; or at pilots who feel the air traffic control system, etc., is complicated beyond the comprehension of the average pilot. This course is directed at removing some of the mystery which has surrounded the use of instrument navigation and communication systems.

If, at the completion of this course, you have been able to gain an insight into the systems discussed, and if you have been able to fly through the maneuvers, in all likelihood you have the capability to earn an instrument rating. It is believed you have the capability because all of the maneuvers required for an instrument rating are simply a combination or variation of the maneuvers practiced in the AOPA 360° Rating Course and the Nav/Com Course.

Yes, there is still a lot of material to be covered. FAA regulations, meteorology, flight planning, en route and approach procedures, and communications must all be covered in more detail. These are subjects on which you have already worked and studied. You already have the foundation built; from this point on, you add to that foundation, layer by layer, while increasing knowledge and skill.

If you find it impossible to actively continue with training, you will find that your ability to recall details and to perform the maneuvers will gradually diminish as time passes. For continued protection, however, it is necessary to maintain final flight check performance. To do this, practice relying solely on your instruments and review the basic control procedures at least once every 30 days. When you are on a cross-country, use all of the nav/com facilities that are available to you.

A suggestion: Pair up with a fellow pilot at your airport. You can act as safety pilots for each other. Be sure to give constructive criticism on each other's performance (Don't use a non-certificated pilot to serve as a safety observer). Don't be satisfied with performance less than what you know you can do. If you need it, schedule extra practices.

See your local instructor at least once every six months. In just one brief half-hour, he can evaluate your performance. If you need instructional assistance, or if you have developed any bad habits, he can put you on the right track before you have gone too long. If your proficiency and procedures are satisfactory, your instructor's assurances should be welcome.

The recommended course of action now is to work with an instructor in your local area and continue to add to your knowledge and skill. Working toward an instrument rating will be both challenging and rewarding. As you have found, the experience will greatly improve your over-all flying. ●

How To Obtain An AOPA Instrument Nav/Com Certificate

When the pilot finishes the Nav/Com training course, his instructor will fill out the blank form and send it to the AOPA Foundation, Inc., 4650 East-West Highway, Bethesda 14, Md. The certificate will be sent to the pilot by the Foundation. For the pilot who desires to continue training, he should practice, in addition to the minimum proficiency requirement, training recommended in Section 6. Specifically the pilot should train a minimum of four hours after each course, reviewing and practicing each test and procedure included in the courses completed.

For Flight Instructors

A properly certificated flight instructor may obtain without cost one copy of the AOPA Instrument Nav/Com syllabus and 10 copies of the Pilot Training Manual by sending his name, address and certificate number to the AOPA Foundation, Inc., 4650 East-West Highway, Bethesda 14, Md. Copies of the syllabus and manual also may be obtained by a fixed-base operator who supplies the Foundation with the names, addresses and certificate numbers of his flight instructors. One copy of the syllabus and 10 copies of the manual will be supplied for each flight instructor listed. Operators and others desiring copies of the manual in bulk may obtain them from the Foundation at cost, $10 per 100 copies. The syllabus, however, will not be available in bulk. Its distribution will be limited to fixed-base operators, flight instructors and others having a bonafide need for it.

References for Further Study

1. **AOPA 360° Rating Pilot Training Manual,** AOPA Foundation, Inc. Copyrighted 1961, AOPA Foundation, Inc.
2. **All Weather Flight Manual,** U. S. Navy, Government Printing Office, chapter 2, 6, 8, 14 through 16, 18 through 22.
3. **Air Force Manual,** AFM-51-38, **Theory of Instrument Flying.,** Part 1 and 2.
4. **Radio and Instrument Flying.** Zweng, Charles A.; Zweng, Alan C. (Pan American Navigation Service) Chapters 1, 2, 3, 4, 5, 6, 7, and 9.
5. **Pilots Radio Handbook,** FAA, 1962.
6. **Rules of Flight,** FAA, September 1962.
7. **Modern Airmanship** edited by Neil D. Van Sickle, Brig. General, U. S. Air Force (D. Van Nostrand Company, Inc.), Chapters 11 and 12.