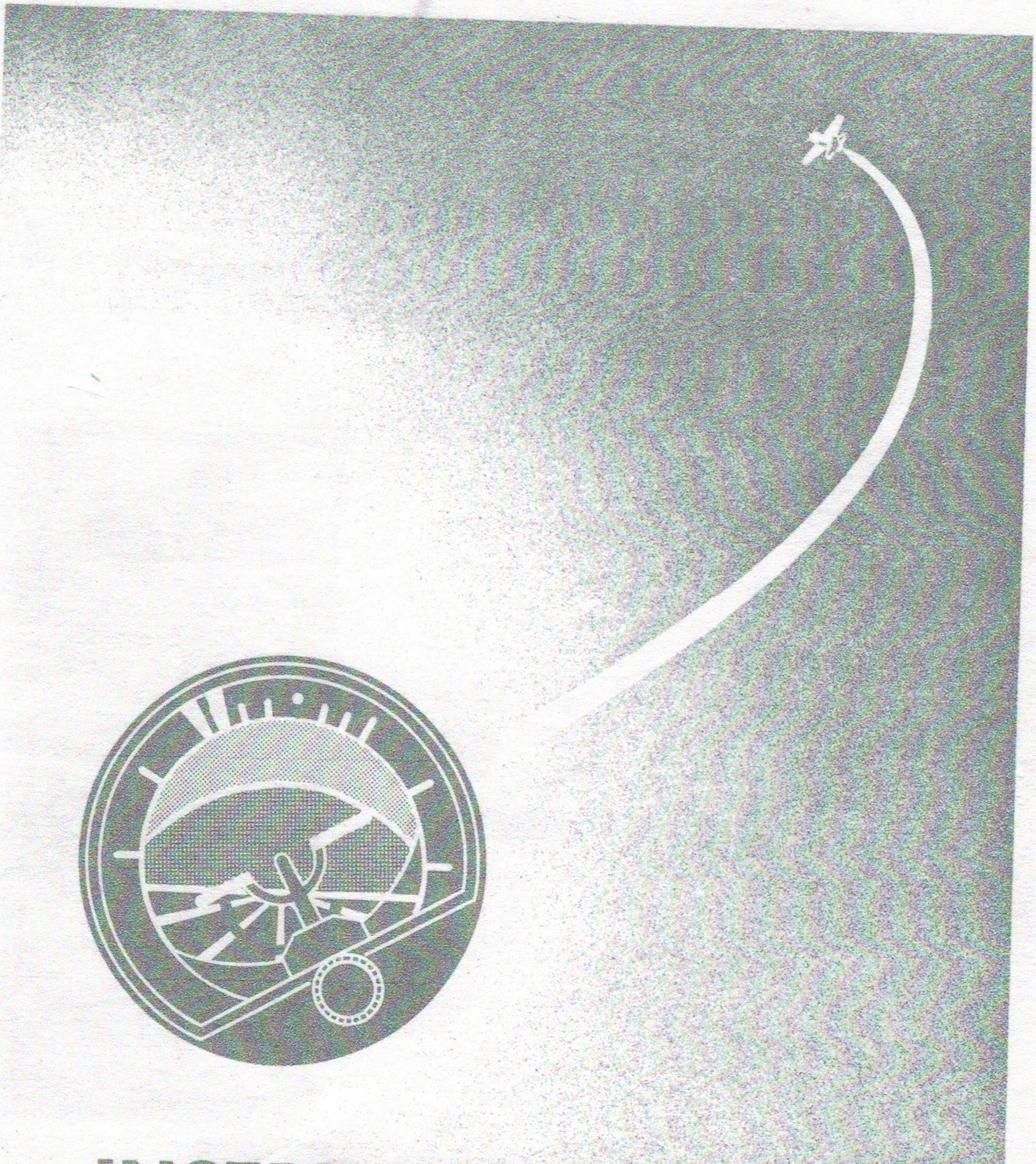
$8.50

AC 61-27C



INSTRUMENT FLYING HANDBOOK

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

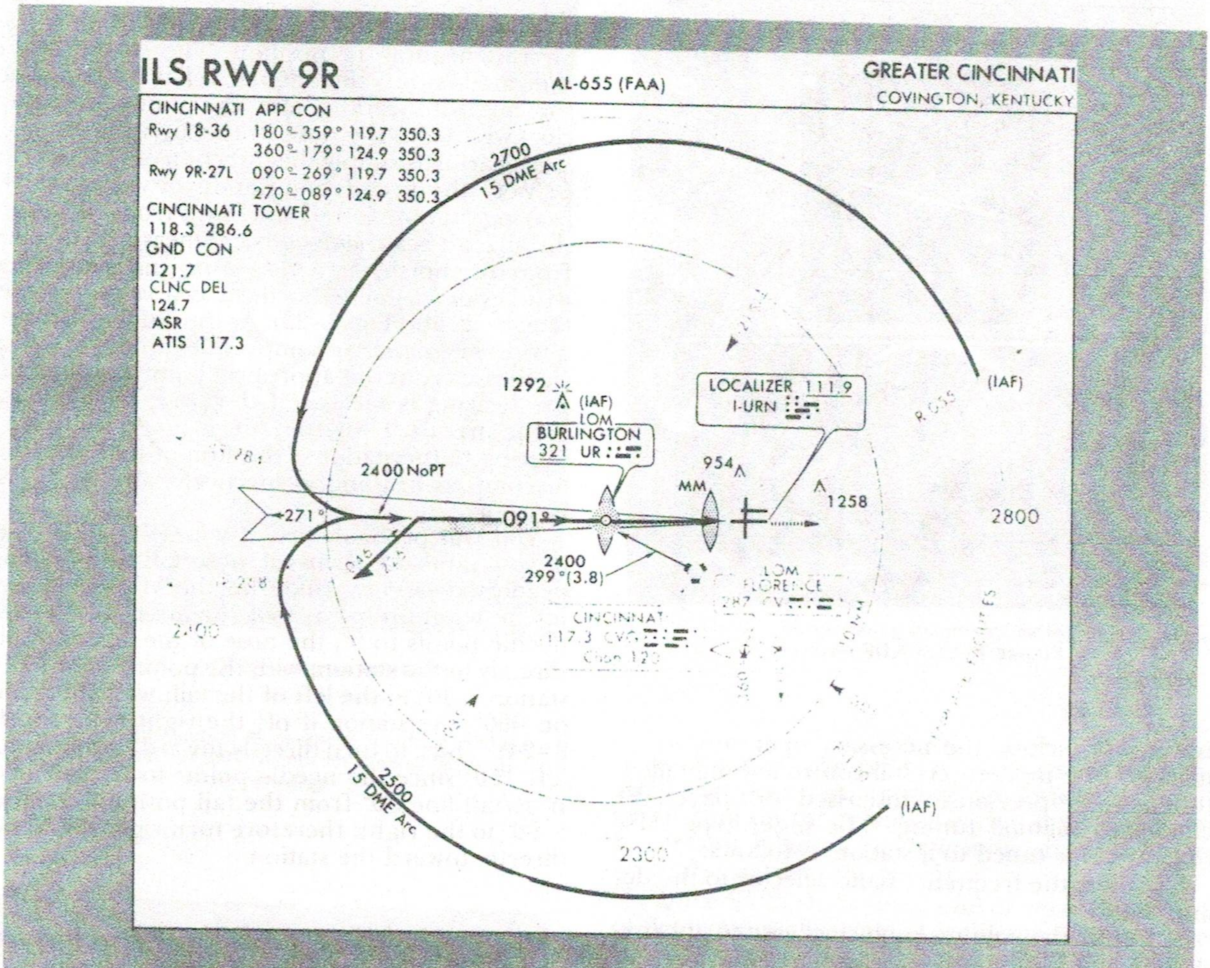


FIGURE 8–20. Localizer interception from DME arc.

the arc. Set the course of the radial to be intercepted as soon as possible and determine the approximate lead. Upon reaching this point, start the intercepting turn. Without an RMI, the technique for radial interception is the same except for azimuth information, which is available only from the OBS and CDI.

The technique for intercepting a localizer from a DME arc is similar to that described above for intercepting a radial. At the depicted lead radial (LR–284 or LR–268 in Fig. 8–20), a pilot having a single VOR/LOCALIZER receiver should set in the localizer frequency. If the pilot has dual VOR/LOCALIZER receivers, one unit may be used to provide azimuth information and the other set to the localizer frequency.

Automatic Direction Finder (ADF)

Knowledge of ADF procedures offers several advantages to the instrument pilot, although many seldom use ADF equipment because of the relatively simpler operation and interpretation of VHF equipment. ADF provides; (a) a backup navigation system in the event of VHF equipment failure; (b) a means of monitoring position en route and providing data for plotting fixes; (c) a navigation system for use in areas and at altitudes where VOR "line-of-sight" signals are unreliable; (d) radio communications (receiver only) on the ground where VHF reception is impossible. Weather broadcasts and clearances can be received, for example, at points outside VHF signal range; and (e) auxiliary and standby navigation information on instrument approaches.

Selection of Station.—An older type ADF receiver is shown in Figure 8–21, and has been described earlier on pages 124 and 125. The receiver illustrated can be tuned to any station between 190–1750 kHz. Included in this range are "H" facilities on Enroute Low Altitude Charts.

Tuning.—Tuning details vary with the type ADF equipment installed in the aircraft. The manufacturer's brochure provided with the particular re-

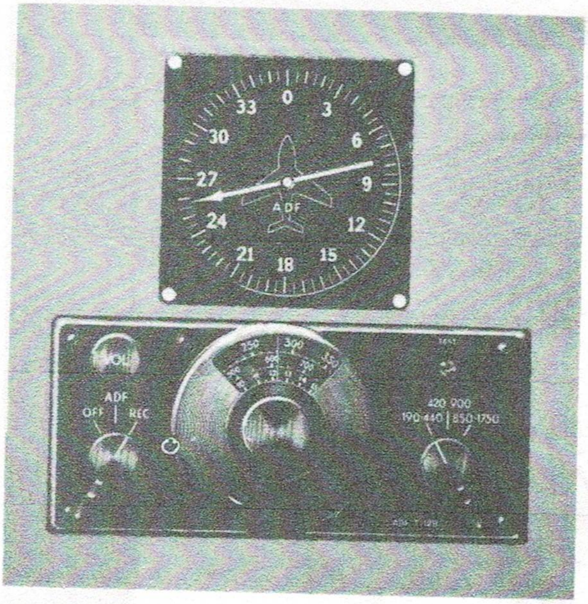


FIGURE 8-21. ADF receiver.

ceiver will include the necessary operating information. The modern crystal-controlled digitalled-tuned ADF previously discussed on page 125 eliminates manual tuning. The older type ADF (Fig. 8-21) is tuned to a station as follows:

1. Adjust the frequency band selector to the desired band.

2. Rotate the volume knob clockwise to approximately half the range.

3. Select "REC" position on the function switch. This selects the sense antenna for tuning the station for use of the receiver as a nondirectional radio receiver. Tuning with the function switch on "ADF" (automatic) position results in unnecessary hunting of the ADF needle as various station signals are received.

4. Rotate the frequency selector to the desired frequency. If a tuning meter is installed with the receiver, it is essential to tune for maximum tuning meter deflection. Without a tuning meter, adjust the frequency selector for maximum signal clarity and identify the station.

5. Select the "ADF" position on the function switch. The ADF needle will rotate until it points to the station. Note the bearing indicated on the ADF dial and push the "test" button. This will rotate the needle clockwise until the test button is released. If the station is tuned properly and the signal is reliable, the needle will return to the bearing previously noted.

6. Adjust the volume to the desired level. Volume adjustment has no effect on operation of the ADF needle.

ADF Orientation.—Unlike the VOR receiver, which indicates magnetic bearing TO or FROM the station without reference to aircraft heading, the ADF needle points TO the station, regardless of aircraft heading or position. The *relative* bearing indicated is thus the angular relationship between the aircraft heading and the station, measured clockwise from the nose of the aircraft.

A bearing is simply the direction of a straight line between the aircraft and station, or vice-versa. The bearing line measured clockwise from the nose of the aircraft is a *relative bearing;* measured clockwise from true north, it is a *true bearing;* measured clockwise from magnetic north, it is a *magnetic bearing* (Fig. 8-22 and Fig. 8-23). As the illustrations show, a true, magnetic, or compass heading is measured clockwise from the appropriate north, and a relative bearing is measured clockwise from the nose of the aircraft. Thus, the true, magnetic, or compass bearing to the station is the sum of true, magnetic, or compass heading, respectively, and the relative bearing.

You will probably orient yourself more readily if you think in terms of nose/tail and left/right needle indications, visualizing the ADF dial in terms of the longitudinal axis of the aircraft. When the needle points to 0°, the nose of the aircraft points directly to the station; with the pointer on 210°, the station is 30° to the left of the tail; with the pointer on 090°, the station if off the right wing tip (Fig. 8-24). Thus, to turn directly toward station A, turn left 150° since the needle points to the left of the nose/tail line 30° from the tail position. Station B is 90° to the right; therefore turn right 90° to head directly toward the station.

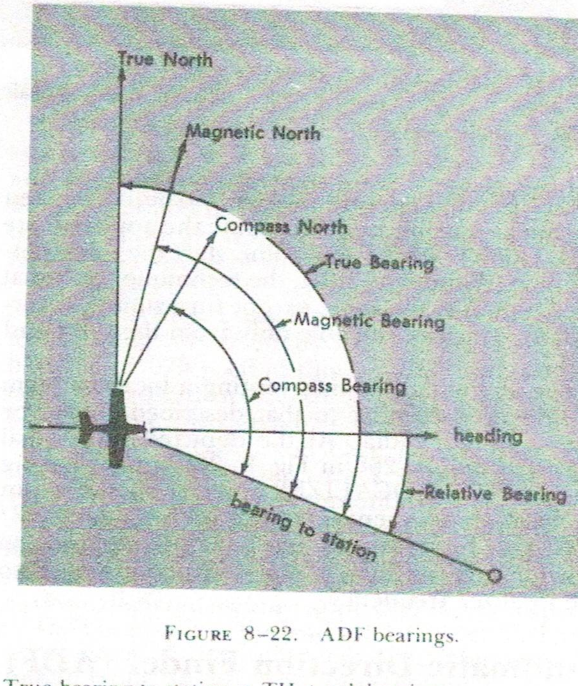


FIGURE 8-22. ADF bearings.

True bearing to station = TH + rel. bearing.
Magnetic bearing to station = MH + rel. bearing.
Station to aircraft bearings are true, magnetic or compass bearings ± 180°.

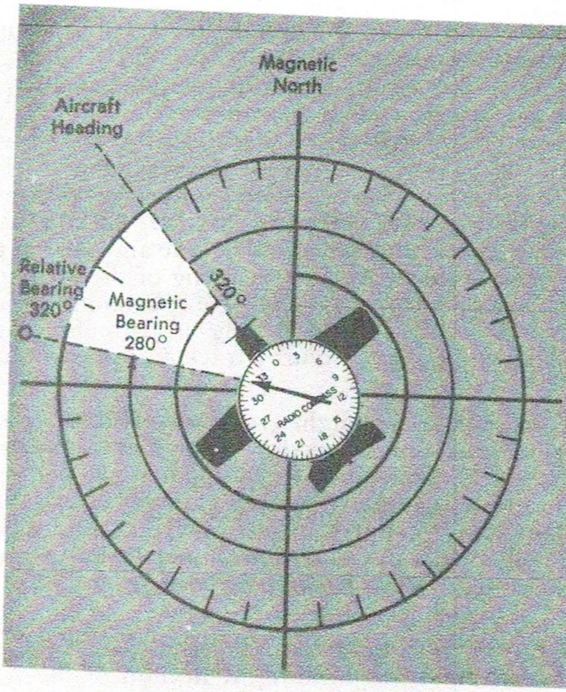


FIGURE 8–23. ADF bearing computations.

Magnetic bearing to station = magnetic heading (320°) + rel. bearing (320°) = 640° or 280° (whenever the total is greater than 360°, subtract 360 from the bearing).

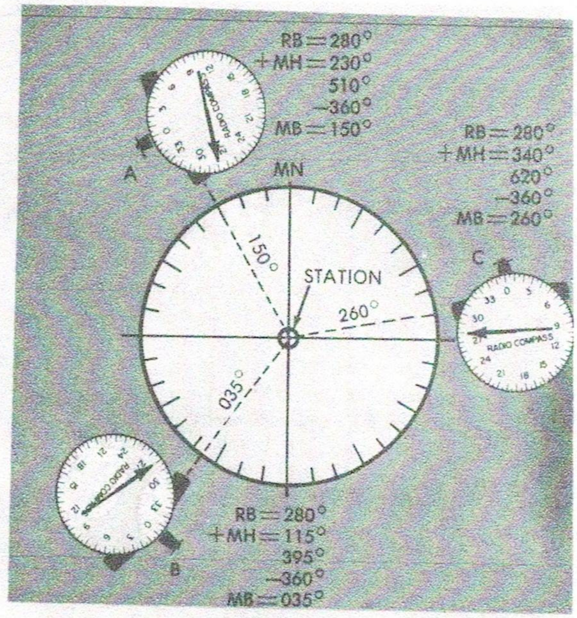


FIGURE 8–25. Determining magnetic bearing to station with ADF.

Note that (a) the relative bearing shown on the ADF dial does not, by itself, indicate aircraft position, and (b) the relative bearing must be related to aircraft heading to determine direction to or from the station (Fig. 8–25).

Figure 8–25 shows only one of several methods of determining bearings—or lines of position—between aircraft and station. Visualizing the 80° left-of-nose indication at all three positions shown, the magnetic bearing to station can be determined by subtracting the left deflection from the magnetic heading:

	A	*B*	*C*
Magnetic heading	230°	115°	340°
Minus left deflection	80°	80°	80°
Magnetic bearing	150°	035°	260°

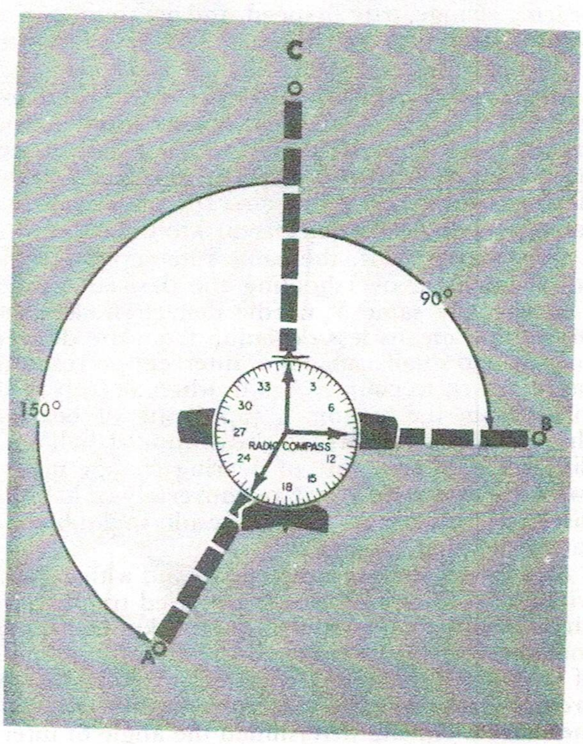


FIGURE 8–24. ADF relative bearings.

Homing.—ADF homing is flying the aircraft on any heading required to keep the azimuth needle on 0° until the selected station has been reached (Fig. 8–26). To head the aircraft toward the station, turn to the heading that will zero the ADF needle. The heading indicator, rather than the ADF, should be used to make the turn. At the completion of the initial turn toward the station, check the ADF needle and, if necessary, zero it with small corrections.

For example, Figure 8–26 shows an initial magnetic heading of 050° and a relative bearing of 302°. A left turn of approximately 60° should zero the needle, heading 350°. After the needle is zeroed, it will remain so unless the heading is changed or crosswind affects the aircraft track. If there is no wind, the aircraft will follow a straight track to the station, assuming constant heading. If a crosswind

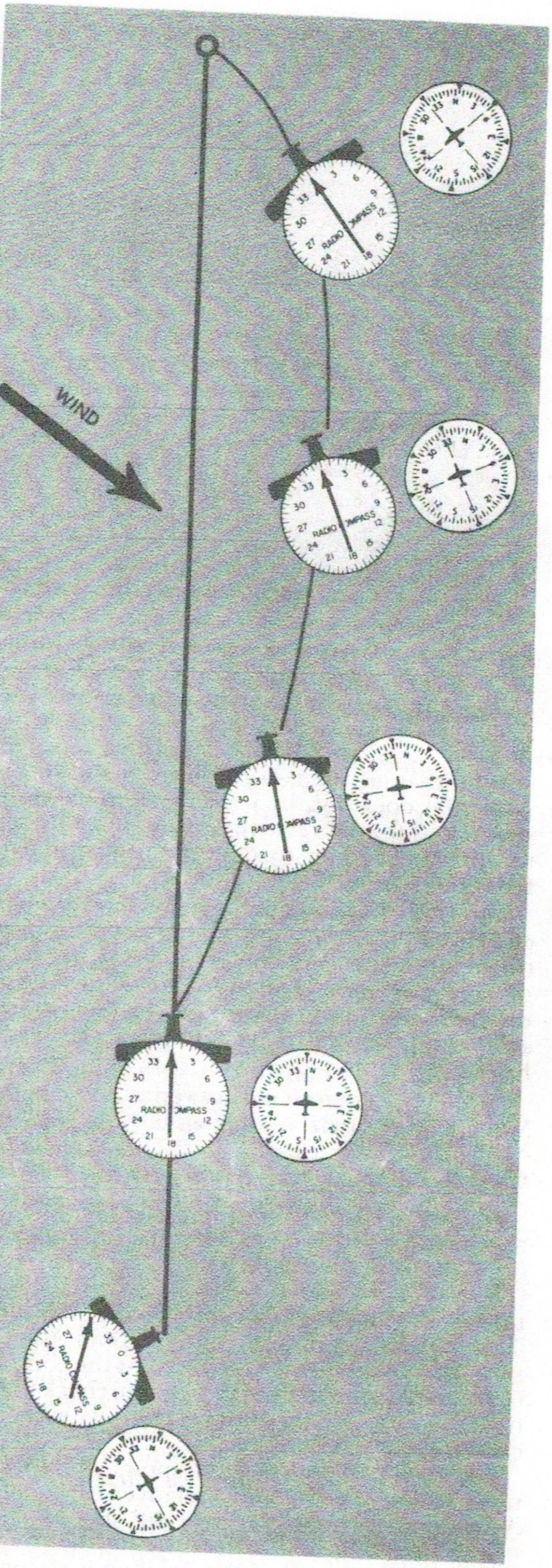


FIGURE 8-26. ADF homing.

drifts the aircraft, the homing track will be a curve as you keep the ADF needle zeroed.

Approach to the station is indicated by increasingly frequent heading corrections to zero the needle, especially when a strong crosswind exists, and by side-to-side needle deflections very close to the station. Passage directly over the station is shown by a 180° reversal of the ADF needle to the tail position; passage on either side and close to the station is shown by a rapid swing of the needle as it continues to point to the station. Homing is easy, though seldom used during instrument flying. Competent pilots control track by more precise procedures.

Tracking.—A straight geographic flight path can be followed to or from a low (or medium) frequency facility by establishing a heading that will maintain the desired track regardless of wind effect. ADF tracking procedures involve interpretation of the heading indicator and azimuth needle to intercept and hold a desired magnetic bearing.

Inbound Tracking (Fig. 8–27).—To track inbound, turn to the heading that will zero the ADF needle. As you hold this heading, deflection of the ADF needle to left or right shows a crosswind (needle left/wind from left; needle right/wind from right). When a definite change in azimuth (2°–5°) shows that the aircraft has drifted off course, turn in the direction of needle deflection (into the wind) to re-intercept the initial inbound bearing. The angle of interception must always be greater than the number of degrees of drift. The magnitude of any intercepting turn depends upon the observed *rate* of bearing change, true airspeed, and how quickly you want to return to course.

A rapid rate of bearing change, *while heading is constant,* indicates either a strong crosswind or proximity to the station, or both. For example, if you are 60 miles from the station with a 3° left deflection, your aircraft is 3 miles to the right of the desired course. In a slow aircraft, use a large interception angle for quick return to the course. In a very fast aircraft, the same interception angle could result in overshooting the desired course. Likewise, the same 3° needle deflection closer to the station means less deviation from the desired course, and smaller angles of interception result in rapid return to course. Again, when aircraft is 60 miles from the station, a rapid rate of bearing change indicates a strong crosswind; at half that distance, the same rate of bearing change means twice the crosswind effect, or conversely, at half the distance, the same wind effect results in double the rate of bearing change.

At a given angle of interception and with a given wind, rate of closure with the desired track varies directly with true airspeed. At 150 knots TAS as compared with 100 knots TAS, the effectiveness of a given interception angle is proportionately greater for the same wind at the same distance from the station. Having determined the angle of interception for return to the desired track, turn toward the track by that amount. As you make the turn

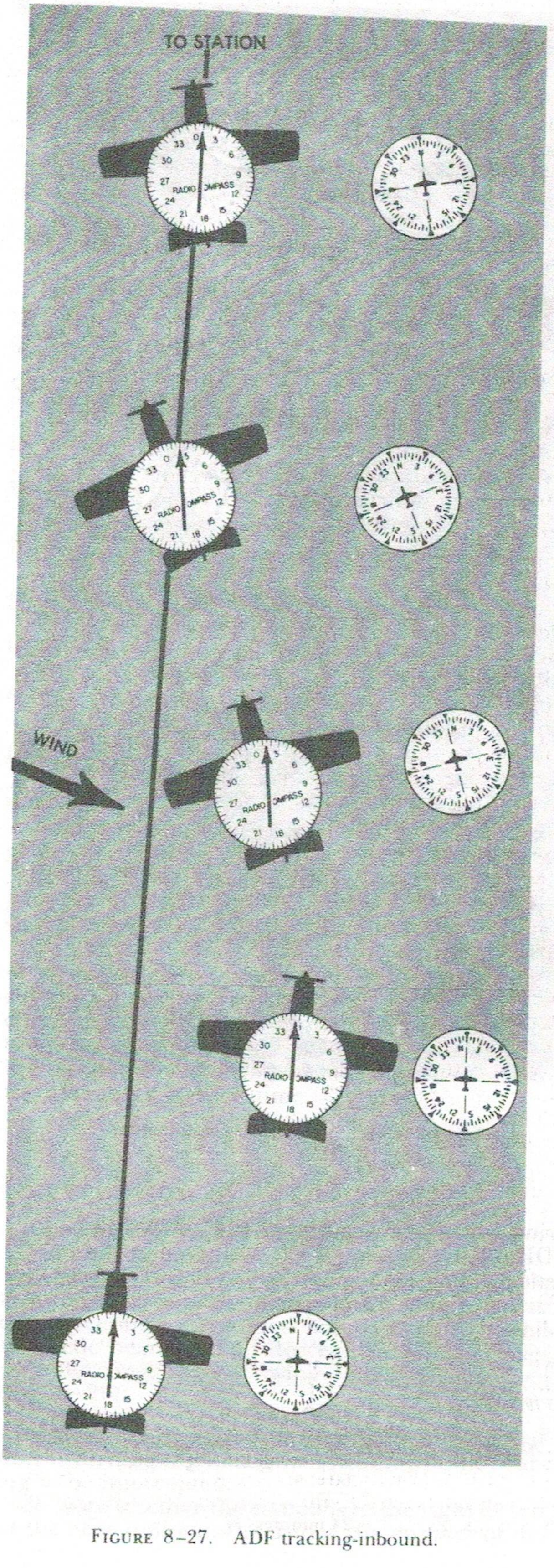


FIGURE 8–27. ADF tracking-inbound.

with the heading indicator, the azimuth needle rotates opposite the direction of turn, and as the interception angle is established, the needle points to the side of the zero position opposite the direction of turn. As you approach the course on a constant interception heading, the ADF needle continues to rotate as the relative bearing changes. When the needle deflection from zero equals the angle of interception, the aircraft is on the desired track. If you begin the turn to the magnetic bearing of the desired track when these angles are equal, you will overshoot the track. In such a case, you can either drift back to track and then establish an estimated drift correction angle, or bracket the track with successively smaller interception angles.

A quicker technique is to lead the turn to the inbound heading before the track is intercepted. The amount of lead depends upon the distance from station, rate of closure observed as you approach the desired track, number of degrees to be turned, and rate of turn. Since these factors are variable, you will develop effective lead estimates as you become familiar with particular aircraft and practice ADF tracking.

After you are back on track, holding an estimated correction for wind drift, you remain on the desired track as long as the azimuth needle is deflected from zero opposite the direction of drift correction, an amount equal to the drift correction angle. If the needle moves further from the nose position, the drift correction is excessive. Reduce the correction angle allowing the aircraft to drift back on course. This is indicated for any drift correction (or interception) angle when ADF needle deflection and drift correction angle are equal. If the estimated drift correction is insufficient, the azimuth needle will move toward the nose, requiring a further correction to regain track. With careful attention to headings, effective drift correction angles can be established with very little bracketing.

Station Approach and Station Passage.—The same suggestions apply to ADF tracking as have been mentioned in connection with ADF homing and VOR/Localizer procedures. The closer you are to

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FIGURE 8–27. ADF tracking—inbound.

1. Turn the aircraft to zero the azimuth needle. Maintain this heading until off-course drift is indicated by left or right needle deflection.
2. When a 5° change in needle deflection is observed, turn 20° in the direction of needle deflection.
3. When the needle is deflected 20° (deflection = interception angle), track has been intercepted. Lead the interception as noted in discussion of tracking. Turn 10° toward the inbound course. You are now inbound with a 10° left drift correction angle.
4. If you observe off-course deflection in the original direction, turn again to the original interception heading.
5. When the desired course has been reintercepted, turn 5° toward the inbound course, proceeding inbound with a 15° drift correction.
6. If the initial 10° drift correction is excessive, as shown by needle deflection away from the wind, turn to parallel the desired course and let the wind drift you back on course. When the needle is again zeroed, turn into the wind with a reduced drift correction angle.

the station, the more aggravated are your errors in drift correction and basic instrument flying technique, unless you recognize station approach and prevent yourself from over-controlling the observed track deviations.

When you are close to the station, slight deviations from the desired track result in large deflections of the azimuth needle. It is important, therefore, that the correct drift correction angle be established as soon as possible after interception of an inbound course. With the course "pinned down" and heading corrections kept at a minimum, you will be more alert to signs of station approach than you would be if you were busy "chasing" headings and ADF deflections. Make small heading corrections (not over 5°) as soon as the needle shows a deviation from course, until it begins to rotate steadily toward a wing-tip position or shows erratic left/right oscillations. At this point, hold your last corrected heading constant, and time station passage when the needle shows either wing-tip position or settles at or near the 180° position. The time interval from the first indications of station proximity to positive station passage varies with altitude—a few seconds at low levels to 3 minutes at high altitude.

Outbound Tracking.—Procedures for tracking outbound are identical to those used for inbound tracking. However, the direction of the azimuth needle deflections are different from those noted during inbound track interceptions, as shown in Figure 8–28. When tracking *inbound,* a change of heading toward the desired track results in movement of the azimuth needle *toward* zero. When tracking *outbound,* a change of heading toward the desired track results in needle movement further *away* from the 180° position.

Time/Distance Checks (ADF).—Time and distance to a station may be calculated with radio-compass procedures similar to the VOR procedures already discussed. A variety of methods commonly used are variations of the basic procedures that follow.

Wing-Tip Bearing Change.—To determine the time/distance to the station, use the following steps:

1. After tuning in the station, determine the relative bearing from the position of the ADF needle.
2. Turn the number of degrees necessary to place the needle on 090° or 270°.
3. Note the time, and fly a constant magnetic heading for a specific number of degrees of bearing change. The amount of change flown varies with the observed rate of bearing change. For example, a 10° change at a considerable distance from the station may take unnecessarily long; the time/distance check can be accomplished in this case by timing a 5° change.
4. Apply the observed time interval to the formula, or calculate the time to station by rule of thumb if a 10° bearing change is used (*see* Time/Distance Checks by VOR). For example, you are

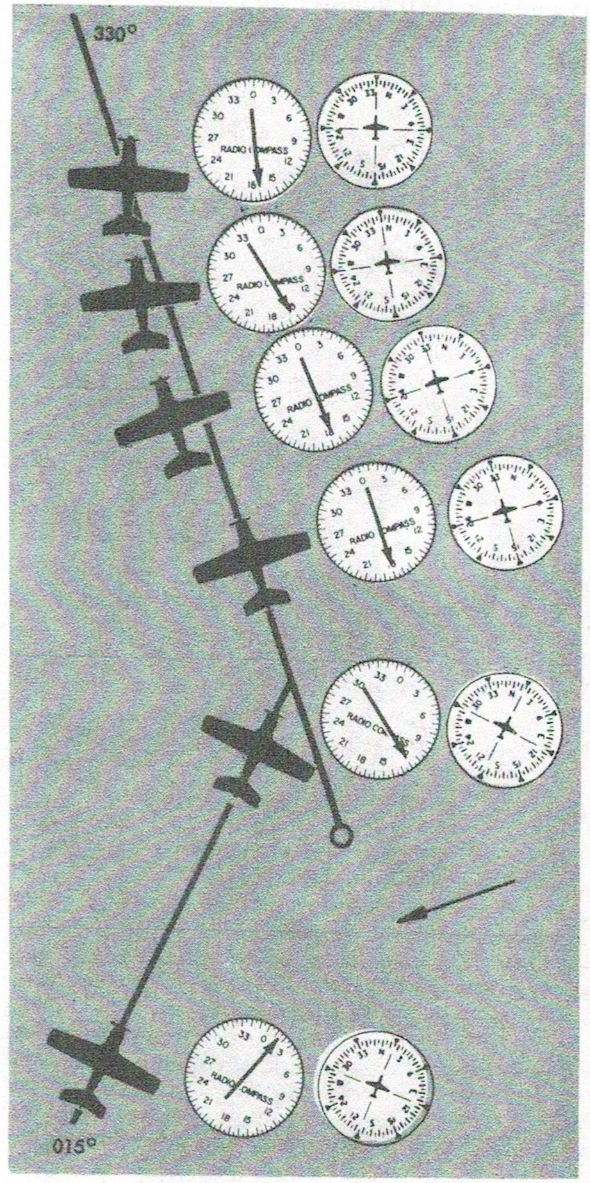

Figure 8–28. ADF tracking-outbound.

flying a magnetic heading of 180°, TAS 130 knots, ADF relative bearing 090°. Maintaining the magnetic heading for 4 minutes, you observe a relative bearing of 100°. Approximate time to station is as follows:

By formula:

$$\text{Minutes to station} = \frac{60 \times \text{minutes between bearing change}}{\text{Degrees of bearing change}} = \frac{60 \times 4}{10} = 24 \text{ minutes}$$

By rule of thumb (for 10° change):

$$\text{Minutes to station} = 6 \times \text{time in minutes between bearing change.}$$
$$= 6 \times 4$$
$$= 24 \text{ minutes}$$

$$\text{or Minutes to station} = \frac{\text{time in seconds}}{10}$$
$$= \frac{240}{10}$$
$$= 24 \text{ minutes}$$

To determine the distance from the station, use the formula (see Time/Distance Checks by VOR) or the following computer method:

1. Place the speed index opposite True Air Speed.
2. Read distance from station on miles scale opposite time from station on minutes scale.

Other time/distance checks are applications of the isosceles triangle principle:

Bow-to-beam bearing gives time to station by the following steps:

1. Turn the number of degrees necessary to place the ADF needle on 045° (or 315°).
2. Maintain heading until the needle is on 090° (or 270°).
3. Time/distance flown equals time/distance to station.

The Double-the-angle-on-bow method involves the following steps:

1. Tune in a station between 10° and 45° off the nose position, and note the relative bearing.
2. Fly a constant magnetic heading until the angle on the nose doubles.
3. The time/distance required to double the angle on the nose equals the time/distance to the station.

The accuracy of time/distance checks involves a number of variables, including existing wind, accuracy of timing, and heading control. Time checks, especially those involving a rapid rate of bearing change, demand very precise techniques in basic instrument flying while you maintain heading and check elapsed time.

Interception of Predetermined Magnetic Bearings

Basic ADF orientation, tracking, and time/distance procedures may be applied to the problem of intercepting a specified inbound or outbound magnetic bearing. To intercept an *inbound* magnetic bearing, the following steps may be used (Fig. 8–29):

1. Determine your position in relation to the station by turning to the magnetic heading of the bearing to be intercepted.
2. Note whether the station is to the right or left of the nose position. Determine the number of degrees of needle deflection from the zero position, and double this amount for the interception angle.
3. Turn the aircraft toward the desired magnetic bearing the number of degrees determined for the interception angle.
4. Maintain the interception heading until the needle is deflected the same number of degrees from the zero position as the angle of interception (minus lead appropriate to the rate of bearing change).
5. Turn inbound and continue with tracking procedures.

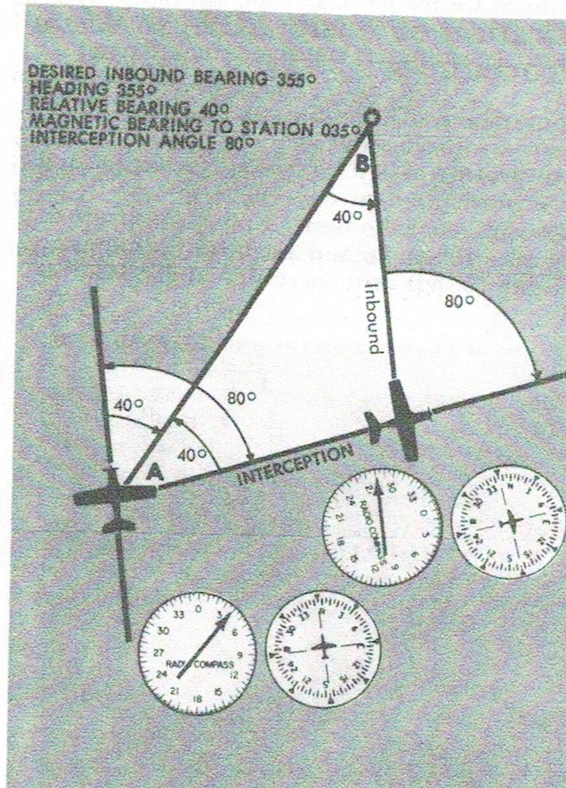

FIGURE 8–29. Interception of predetermined magnetic bearing.

Note that this method combines inbound course interception with a time estimate to the station, since the interception leg and the inbound leg are equal sides of an isosceles triangle. The time from the completion of the turn to the interception heading (075°) until interception of the desired inbound bearing is equal to the time-to-station (double-the-angle-on-bow).

Interception of an *outbound* magnetic bearing can be accomplished by the same procedures as for the inbound intercept, except that you substitute the 180° position for the zero position on the azimuth needle.

Application of Basic ADF Procedures

Assume that you have departed airport "X" to fly direct to a destination airport via an inbound magnetic bearing of 020° to the "H" facility located on the airport. See Figure 8–30.

1. You intercept the desired inbound magnetic bearing at a 45° angle and establish the inbound track with a 10° left drift correction angle, heading 010°.

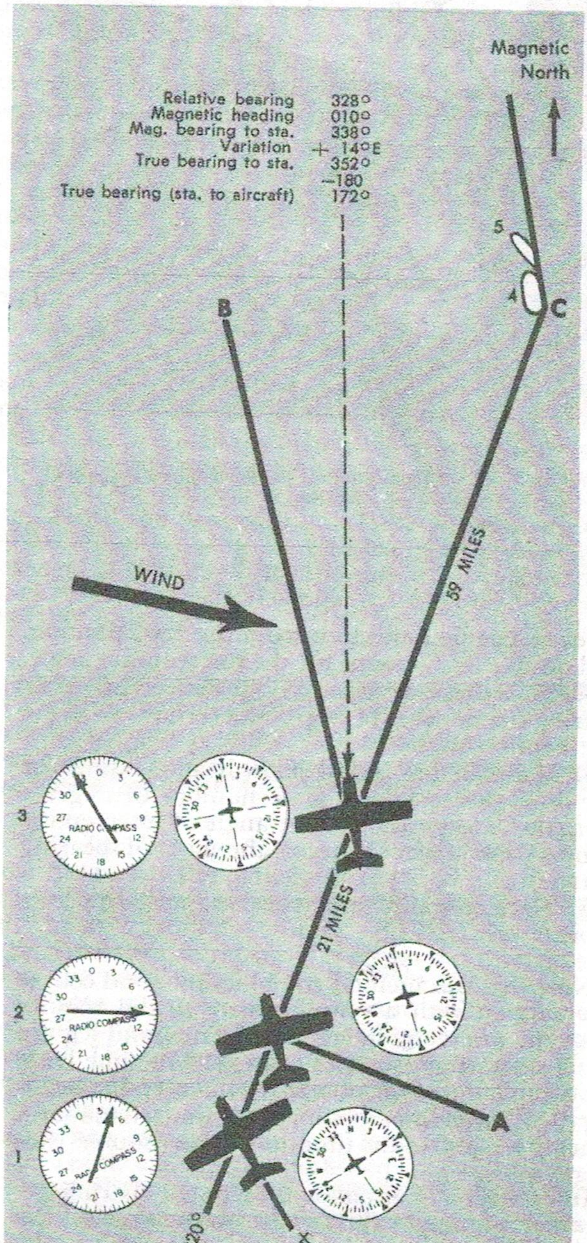

FIGURE 8–30. Application of ADF procedures.

2. *Plotting Position.*—Tuning in nondirectional beacon "A", note the time as the ADF needle indicates 100°. With a 10° left drift correction angle, your position is 90° to the station. The fix can be directly located on the inbound track line drawn on your aeronautical chart. Move your plotter along the track line until the 090 reference line intersects the station.

3. You establish another fix by tuning in nondirectional beacon at "B", noting 9 minutes elapsed time as the ADF shows a relative bearing of 328°. Adding the relative bearing and magnetic heading, the magnetic bearing to the station is 338°. To plot the fix on your chart, the magnetic bearing must be converted to a true bearing *from* the station. Assuming 14°E variation, the true bearing from the station is 172°, which fixes your position 21 nautical miles from the one established 9 minutes earlier. From this data you compute groundspeed as 140 knots and estimate arrival time at your destination after measurement of the remaining distance.

4. Holding should be accomplished in the pattern depicted on the chart unless ATC instructs you otherwise. The depicted holding pattern will normally be aligned with the final approach course to the airport to facilitate letdown and approach to the field. The ADF approach combines the basic procedures you have already studied—orientation, tracking inbound and outbound, and interception of predetermined bearings.

Figure 8–31 illustrates a standard holding pattern (dotted line shows holding entry), as well as the procedure turn for approach to the airport. Holding may or may not be necessary, depending upon traffic and weather conditions. If you hold as illustrated, your entry would be as specified in the *Airman's Information Manual.* The appropriate communications procedures are explained in a later chapter of this text. Assuming a 10° left drift correction angle as you track inbound on the 020° magnetic bearing, proceed as follows:

a. Turn to parallel the outbound course as the ADF needle indicates station passage, applying drift correction appropriate to the known wind. Note the time.

b. Fly the outbound heading for approximately one minute, observing the ADF needle for drift toward, or away from, the inbound holding course. If you apply a 10° left drift correction angle, drift away from course will be shown by movement of the needle farther from the 180° position or by failure of the needle to move toward the tail position as you proceed outbound.

c. Turn toward the inbound course, rolling out on a 125° magnetic heading for a 45° interception of the inbound course. Note the relative bearing immediately. If it is greater than 045°, you have overshot the inbound course and may have difficulty establishing the track before passing the station.

d. Lead the turn to the inbound course (170°) and roll out with drift correction. If you are on course, your drift correction angle will be equal and opposite to the ADF needle displacement from zero.

e. Track inbound, using small corrections. The quicker you establish the desired track, the fewer your holding problems since both basic flight techniques and procedural details will keep you busy.

f. Turn outbound on station passage, noting the time. With no wind, timing the outbound leg would begin as you roll out on a 350° heading with the ADF needle reading 090°. With the wind as shown, your track would be closer to the station than shown in the diagram.

g. Roll out on an outbound heading with a drift correction angle equal to double the amount of inbound drift correction. As you begin outbound timing for one minute, your ADF will indicate approximately 110°, assuming a 20° left drift correction angle. As you maintain the outbound heading, the needle moves toward the 180° position. With experience, you learn to recognize drift by rate of movement of the ADF needle—rapidly toward the tail position if you drift inward or a strong tailwind exists; slowly toward the tail if you drift outward or a strong headwind exists.

h. With correct inbound and outbound drift correction angles, your ADF should read zero, plus or minus the appropriate drift correction angle, as you complete the turn to track inbound.

i. The approach is normally begun directly from the holding pattern, tracking inbound as you descend and execute a low approach to the field.

5. *Procedure Turn and Low Approach.*—When a final approach from a nondirectional beacon holding pattern is not authorized, a procedure turn is required for course reversal. For execution of the procedure turn and approach shown in Figure 8–31, the approach procedure depicted on the approach chart for the airport would be used. At this point, you are concerned with the application of basic navigational techniques to the problem. The associated procedures are shown on the illustration.

To track outbound and reverse course to the final approach, proceed as follows:

a. On station passage, note the time, and turn outbound to intercept the 350° magnetic bearing.

b. Start the procedure turn to 305° as soon as practicable, normally within 2 minutes of station passage. Hold the 305° heading for 40 seconds to 1 minute, depending upon the existing wind.

c. Turn inbound to intercept and track the 170° magnetic bearing to the field.

The suggestions discussed earlier with respect to station approach are of particular importance during the low approach. An ADF instrument approach executed without additional navigation airborne equipment or radar assistance demands a high level of skill in the use of both basic flight

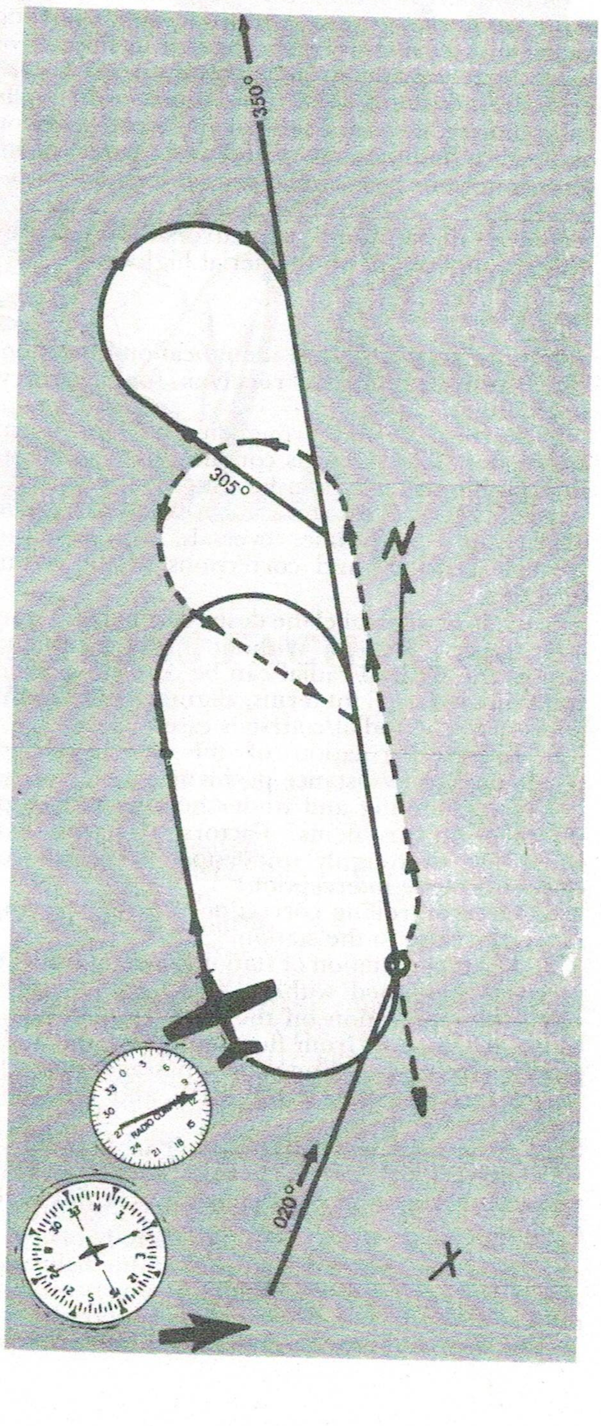

FIGURE 8–31. Transition to ADF approach.

1. Check radio contact with Air Traffic Control before arrival over station. Maintain assigned altitude, or if cleared for approach, descend to initial approach altitude.
2. Turn outbound, reduce speed if necessary, note time, report station passage to ATC, and perform prelanding check.
3. Descend to procedure turn altitude given on approach chart.
4. Procedure turn in direction shown on approach chart.
5. *Inbound,* descend to minimum altitude over final approach fix, then to MDA.
6. *Inbound,* report over final approach fix and complete approach to landing. If field is below minimums, report and execute missed approach depicted on approach chart, or as directed by ATC.

and navigation instruments, as well as facility with communications procedures. It is essential that you be thoroughly familiar with courses, altitudes, and procedural details well *before* you execute the approach in order that you be able to visualize the details in their necessary sequence.

Common Errors in the Use of Navigation Instruments

Other than the specific errors outlined below, the errors underlying most confusion while learning navigation techniques relate to skill in the use of basic flight instruments. You cannot read a VOR or ADF indication while you fumble with pitch, bank, power, and trim control any more than you can read a highway sign or follow a cloverleaf intersection while you stare at your automobile brake pedal.

Mastery of basic flight maneuvers is prerequisite to their application on the aerial highways.

VOR Errors

1. Careless tuning and identification of station.
2. Failure to check receiver for accuracy/sensitivity.
3. Turning in the wrong direction during an orientation. This error is common until you visualize position rather than heading.
4. Failure to check the ambiguity indicator, particularly during course reversals, with resulting "reverse sensing" and corrections in the wrong direction.
5. Failure to parallel the desired radial on a track interception problem. Without this step, orientation to the desired radial can be confusing. Since you think in left/right terms, aligning your aircraft position to the radial/course is essential.
6. Incorrect rotation of the course-selector (OBS) on a time/distance problem.
7. Overshooting and undershooting radials on interception problems. Factors affecting lead should be thoroughly understood, especially on close-in course interception.
8. Overcontrolling corrections during tracking, especially close to the station.
9. Misinterpretation of station passage. On VOR receivers equipped without an ON/OFF flag, a voice communication on the VOR frequency will cause the same to/from fluctuations on the ambiguity meter as shown on station passage. Read the *whole* receiver—TO/FROM, CDI, and OBS—before you make a decision.
10. Chasing the CDI, resulting in homing instead of tracking. Careless heading control and failure to bracket wind corrections makes this error common.

ILS Errors

1. Failure to understand the fundamentals of ILS ground equipment, particularly the differences in course dimensions. Since the VOR receiver is used on the localizer course, the assumption is sometimes made that interception and tracking techniques are identical when tracking localizer courses and VOR radials. Remember that the CDI sensing is sharper and faster on the localizer course.
2. Disorientation during transition to the ILS due to poor planning and reliance on one receiver instead of on all available airborne equipment. Use all the assistance you have available; the single receiver you may be relying on may fail you at a busy time.
3. Disorientation on the localizer course, basically due to the first error noted above.
4. Incorrect localizer interception angles. A large interception angle usually results in overshooting and often disorientation. Turn to the localizer course heading immediately upon the first indication of needle movement, using a small interception angle whenever possible. An ADF receiver is an excellent aid to orientation during an ILS approach.
5. Chasing the CDI and glide path needles, especially when the approach is not sufficiently studied before the flight. Flying the proper headings, altitudes, rate of descent, times and power configuration settings is impossible if your mind is on studying the approach chart.

ADF Errors

1. Improper tuning and station identification. Homing or tracking to the wrong station has been done by many students.
2. Dependence on homing rather than proper tracking, commonly results from reliance on the ADF indications instead of correlating them with heading indications.
3. Poor orientation, due to failure to follow proper steps in orientation and tracking.
4. Careless interception angles, very likely if you rush the initial orientation procedure.
5. Overshooting and undershooting predetermined magnetic bearings, often due to forgetting the course interception angles used.
6. Failure to maintain selected headings. Any heading change is accompanied by an ADF needle change. The instruments must be read in combination *before* any interpretation is made.
7. Failure to understand the limitations of the radio compass and the factors that affect its use.
8. Overcontrolling track corrections close to the station (chasing the ADF needle), due to failure to understand or recognize station approach.
9. Failure to keep heading indicator set with magnetic compass.