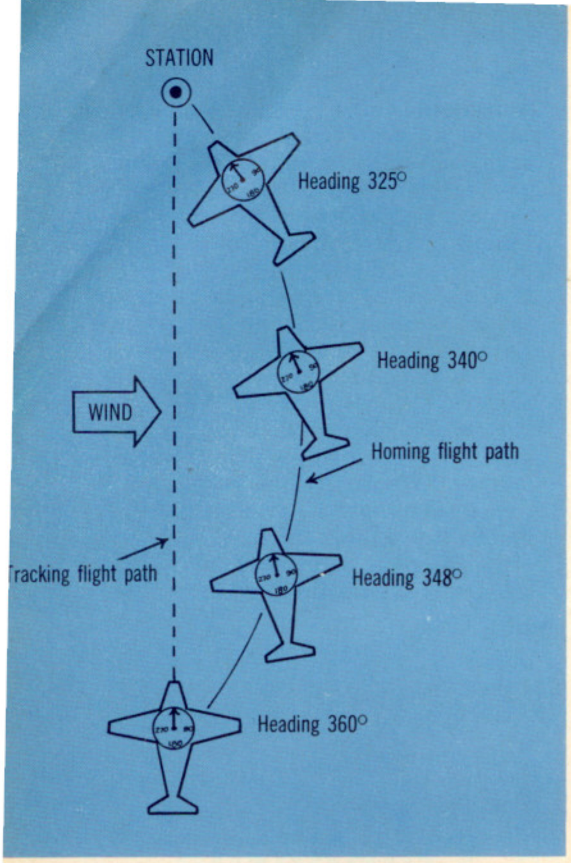

FIGURE 1 Crosswind gives curved track, with curvature increasing as station is reached

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Secret of ADF Tracking

Automatic direction finder still has its place in today's flying despite development of omni and distance-measuring equipment (DME). This article tells you how to get full utility from your ADF

Don't sell ADF navigation short! With all due respect to omni and DME, navigation by ADF in the LF/MF radio spectrum still has its place in today's flying. The ability to use the versatile ADF (automatic direction finder) can afford several advantages, such as:

1. An alternate navigation system, should your omni receiver or the VOR Station go sour.

2. In remote parts of the United States, and in many areas of our neighboring countries, omni is not available as yet. Precise navigation over such areas usually can be performed with the ADF tuned to radio ranges, nondirectional radio beacons, or compass locators of an ILS system which fall generally in the 200 to 400 kc band; or tuned to some types of general broadcast stations in the 550 to 1600 kc band.

3. Low frequency and medium frequency signals do not have "line-of-sight" characteristics as VHF signals, and in many cases strong LF/MF signals can be tuned in on the ADF while the aircraft is on the ground at the point of departure. When this is so, and under conditions of marginal visibility, navigation can literally be from the ground at point "A" to the runway at destination, point "B."

However, many VFR general aviation pilots fail to receive full utility from their ADF's, because they use them for "homing" only and avoid "tracking" because of the mental gymnastics involved.

Homing with the ADF is very easy to perform. The station is tuned in and the aircraft is flown to keep the ADF indicator needle on zero. The aircraft will fly to the station. If a crosswind is present, this affects a curved track to the station (see Figure 1) with the curvature usually increasing as the station is approached.

As Figure 2 shows, homing is not precise navigation, as the aircraft's track over the ground to the station is at the whim of the wind, and is somewhat unpredictable. This loose form of navigation cannot be used in IFR work. Also, homing can be used only when inbound to a radio station, and never when outbound from a station.

Tracking, on the other hand, is more precise navigation and can be used when either inbound or outbound from a station, and is the basis for an ADF approach. The term tracking can be defined as flying a series of headings toward or away from a station, making corrections for drift as it is determined. This results in a series of straight-line tracks, but ends up with a straighter and more direct track than homing (see Figure 1).

A companion term to tracking is "intercepting"—this is a relatively simple technique by which you intercept a specific inbound or outbound bearing to a radio facility. More about this later.

Hence, by "intercepting," you locate and establish the aircraft on a specific bearing to or from a station, and then by "tracking," you keep the aircraft on that bearing and track into the station on as straight a line as your proficiency will allow.

Admittedly, to intercept a bearing and track by ADF does call for a few more mental gymnastics than omni, but it does come easily if you establish a clear understanding in your mind of the following:

Compass Rose—(see Figure 2). Perform a few memory exercises on a compass rose divided by 30° increments. Visualize it in your mind, so that you can "spot" any radial, and immediately determine which way and how many degrees to turn to a specific heading. Drill on figuring reciprocals, too, by using the 30° increment system.

For example, to determine the reciprocal of 38°, you might use the system this way. The base figure is 30° (closest major increment) plus the 8° remainder. From your mental picture of the compass rose you "see" that the reciprocal of 30° is 210, and this major increment plus the 8° equals a reciprocal heading of 218°.

Relative Bearing—The important characteristic of the ADF indicator needle is that it will point to the station which has been selected. When you turn the aircraft to have the ADF needle center on zero, the station is located straight-away from the nose. If the needle points to 090° on the ADF indicator scale, the station is off the right wing; when it points to 180°, the station is directly behind the aircraft; a reading of 270° would indicate that the station is off the left wing.

The textbook tells us in view of the above, "relative bearing" is the angular direction of the station clockwise from the nose of the aircraft, and the specific number of degrees is read under the head of the ADF needle. However, in using the ADF you probably will find yourself thinking of relative bearing as so many degrees to the left or right of the nose, or of the tail of the aircraft, depending upon whether you are tracking inbound or outbound from a station. By accepting the latter definition, you can, in my opinion, simplify intercepting and tracking techniques.

Track In and Track Out—The terms, "track in" and "track out" correspond to "to" and "from" as used in omni flying. When you track in, be sure to keep in mind that you must intercept the track *before* arriving over the station. When you track out, you intercept the track *after* having flown over the station, as indicated by a 180° reversal of the ADF needle.

Well, now that we have established a few fundamentals, let's see how we can apply same to some problem solving. With reference to Figure 3, let's conjure up a situation where you are flying over sparsely populated country in uncontrolled airspace, where visibility is about one and one-half miles due to a heavy layer of haze which extends up to 7,000 feet. From your last check point you know you are southeast of your airport of destination, and you can now receive a readable signal on your ADF from the nondirectional radio beacon, which is located west of your destination. At this point, you elect to navigate to the airport by ADF.

In this situation, ADF offers two methods. If you decide to home in on the station, and with a crosswind from the north, it is possible that the curved flight track would be such that in marginal visibility you would not see the airport, making it necessary to back track from the station.

The other choice would be to extend a line out from the station to pass through the center of the airport, and then measure its magnetic bearing from the station. In this case it is 90°. It can be seen that if you intercepted that line or bearing at a point east of the airport, and tracked in to the station at 270° (reciprocal of 90° "from" the station), the track would take you right over the airport.

Since this a more precise and quicker way to locate the airport, you plan to intercept and track in to the station on the 270° bearing. Now to accomplish this, you must take the following steps:

Step 1—(all following references are to Figure 3). As soon as you have decided to track in on 270° to the station, turn the aircraft to that heading to set up a parallel course. This move will place you at point "A." Figure 3. By paralleling the desired track, you can determine:

(a) Whether the station is in front of or behind the aircraft. If the ADF needle comes to rest in the upper half of the ADF azimuth scale, the station is ahead; if the needle points to a reading in the lower half, the station is located somewhere behind the aircraft.

(b) Whether your desired track is to the left or right of your present position. If the ADF needle points to the right of 0 (when inbound to a station, or to the right or left of the 180° mark when outbound from a station), the desired track is off to the right; if the point of the needle is left of 0, the track is off to the left.

Let us assume when the aircraft is on the 270° heading at point "A," the ADF needle points to the right of zero and rests on 20°. This means the relative bearing to the station from your position at point "A" is 20°, and your desired track is somewhere over to the right.

How do you get on the desired track by applying the information you have received from the ADF? The answer to this question leads into the next step.

Step 2—In observing Figure 3, you can see that if you altered your course to the right for the number of degrees of the relative bearing (heading of 270 plus R/B of 20, or a new heading of 290°), it would, in a no-wind situation, take the aircraft to the station, and not to the airport. It is apparent then, that any alteration of course, or "cut" to the right

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FIGURE 2 Compass rose

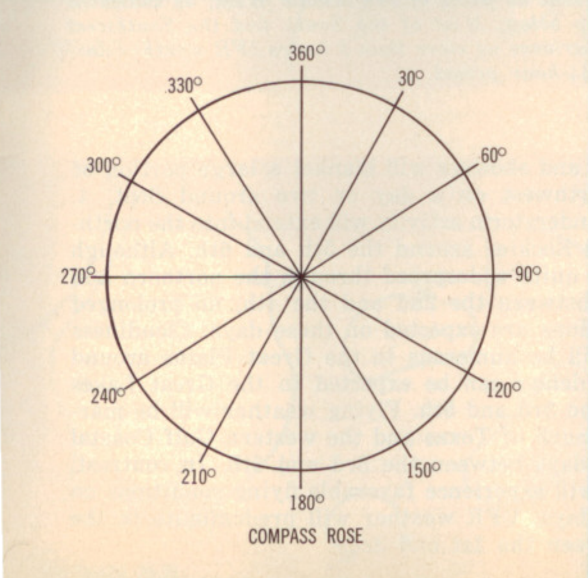
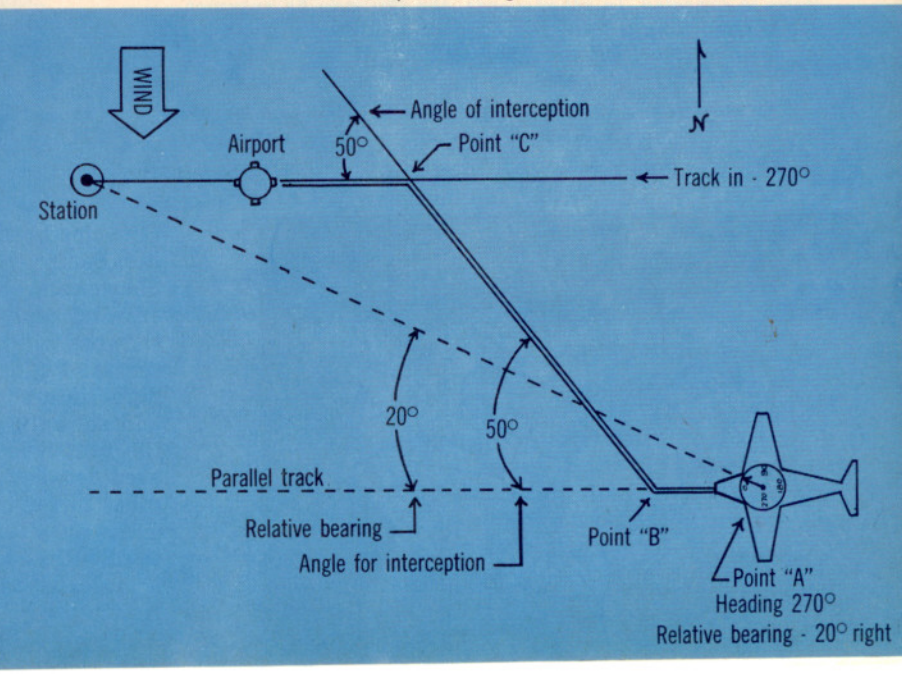


FIGURE 3 Example of tracking into a nondirectional beacon at 270°



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must be in excess of the relative bearing, if you hope to establish the aircraft on the 270° track before you get to the station.

Now the question pops up—how much of a cut to make? The specific answer to this question involves such factors as: distance from the station, true airspeed, existing wind, and how quickly you wish to make the interception. This could develop into quite a problem, but many pilots bypass it by using an effective rule-of-thumb which Sundorph Aeronautical Corporation of Cleveland, one of the first instrument schools in the United States (incorporated 1930), passes on to their instrument students. They suggest that:

When the relative bearing is less than 40°—use an intercept angle which is double the relative bearing plus 10°.

When the relative bearing exceeds 40°—use an intercept angle equal to 90°.

From the above guide, you can now figure your cut to intercept the track. Since the relative bearing at point "A" (Figure 3) is 20°, the angle for intercept will be:

20 x 2 = 40°, plus 10, totals 50°

The new heading will be 270° (present gyro reading) plus the intercept angle of 50°, or 320°. At point "B" on Figure 3, the aircraft is turned to a gyro heading 320°, and you are on your way to intercept the desired track.

Step 3—As you proceed on the cut heading of 320° (from point "B" to point "C"), you will notice that the ADF needle will move toward zero and then to the left of zero. It is the movement of the ADF needle that will keep you posted on your progress toward the desired track.

Since the angle *for* interception is equal to the angle *of* interception at point "C" (parallel track basis), you will know when you arrive by reading the ADF indicator. Remember, the angle for interception was 50° (20 x 2 plus 10), and was based on a right turn from zero on the ADF azimuth scale. So if you count to the left of zero for an equal number of degrees, you will determine the key spot. Zero or 360 minus 50 equals 310.

When the ADF needle travels left and points to the 310° mark on the azimuth circle, the aircraft has intercepted the desired track.

At this time you turn the aircraft to a heading of 270° (inbound to the station), and the ADF needle returns to zero. Your position on the desired track is confirmed by a reading of 270° on the directional gyro, and with the ADF needle resting on zero to indicate the station is directly ahead.

Step 4—Now that you have latched on to the 270° track, you can relax for two or three minutes. And, of course, while you are resting, you should keep an eye on the gyro compass for the correct heading, and pick up any indication of wind drift as reflected in movement off zero of the ADF needle. Tracking, the technique to stay on a selected track, is in part small-scale intercepting, and in part determining a heading to compensate for drift. When you detect a distinct change of 3 to 5° (left or right off zero) of the ADF needle, it is time to get back to work, lest you should lose the track.

Getting back to the navigation problem of Figure 3, let us assume that drift to the left is indicated by the ADF needle pointing to 005° (5° to the right of zero). This, of course, means that the track is on the right, so a cut is taken to right. Once re-established on the desired track, the gyro heading of 270 is now altered with a 5° correction for left drift. New heading is 270 plus 5, or 275. However, you will now note with the revised heading of 275, the ADF needle will indicate 5° to the left of zero (or 355° on the azimuth scale). If the ADF needle maintains its position of 5° left as you hold a gyro heading of 275, then you have pinned down the drift correction, and the aircraft will track in to the airport as desired.

Usually, it may take a little juggling of the gyro heading to pin down the drift correction. If after regaining the track plus a drift correction, you observe the ADF needle sliding toward zero, the amount of the drift correction was not sufficient. Shoot another intercept.

On the other hand, if the needle moves farther away from zero, the drift correction was too large. Recovery from this situation is easier. Turn the aircraft back to the original no-wind heading, and let the wind blow you back on course.

The ADF needle will post you when on the desired track by returning to zero. When this occurs, take up a new heading,.which includes a smaller drift correction.

Tracking Outbound from a Station—After passing over a station, and you desire to track out on a selected bearing, the game of numbers and angles follows the same routine as when intercepting and tracking in—with the exception, that the basic reference point on the ADF azimuth scale is the 180° mark and not the zero. Now all reference is off the tail of the aircraft, rather than the nose.

At first, it may take one or two practice sessions to feel mentally comfortable when using the 180° point as the datum, but the procedure follows easily, if you keep a mental picture of a compass rose around the station from which you are outbound.

Probably the key to precise and enjoyable navigation by ADF is the ability to hold a heading. For once you become proficient in this, the ADF needle then can tell you many interesting facts expressed as little numbers found around the azimuth circle. If you have an ADF aboard your aircraft, put it to work beyond just homing to a station—intercept, track inbound and outbound, make time/distance checks, ADF approaches—learn what a versatile piece of equipment it can be. END