

# HOLDING

My student, Bill, was flying as we approached the VOR from the west to hold northeast. There was a strong northwest wind and we were south of the airway most of the time; the CDI was left of center. As we passed abeam of the VORTAC, the flag changed to FROM, we turned to the reciprocal of the holding course, and Bill dialed the inbound course. Naturally, the left crosswind carried us further from the course.

At the end of a minute we turned left 180° and took up the inbound heading to complete our parallel entry, but were still on the non-holding side, as was shown by a right needle. Naturally, the wind continued to carry us further onto the non-holding side and as the needle reached full scale, I wondered if we were still within protected airspace.

For traffic separation, ATC reserves an area of protected airspace around any holding aircraft, from which all other IFR traffic is banned. The amount of airspace protected for a holding pattern increases with altitude, but in a one minute holding pattern at a VOR at any altitude, the airplane will be within the protected area as long as the CDI is deflected less than full scale.

We passed the fix again and turned right. The flag changed back to TO, but the needle stayed to the right. We were still on the non-holding side. The correct action would have been to correct towards the course and make the inbound turn to the left, trying to intercept. Unfortunately, Bill failed to recognize the meaning of the right needle, became disoriented,

and turned "inbound" to the right, carrying us further to the non-holding side.

It was a practice flight in VFR conditions, and we were not on a clearance, so I refrained from criticizing and waited to see what would develop. Each outbound turn was compressed by the northwest headwind, and each inbound turn was extended by the tailwind, carrying us further and further from the protected area. The resulting pattern is shown in figure 7-1. I believe this is what radar controllers call "spaghetti." An embarrassing picture that, in real weather, would be far from safe.

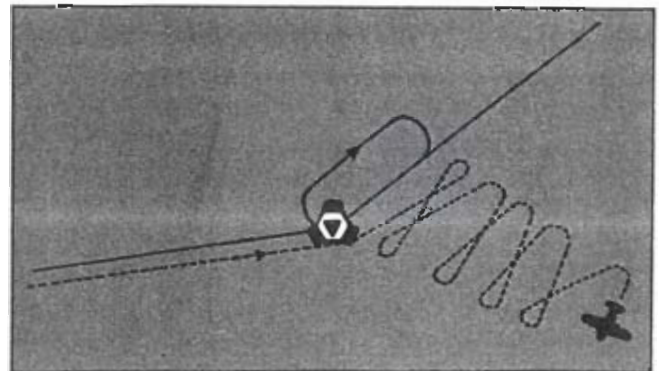


Figure 7-1

The exercise continued for several circuits, about 20 minutes, before I discontinued it. I realized in retrospect that it had been a waste of valuable training time. It also showed an error in course organization: understanding of orientation and wind effects should

have been thoroughly covered on the simulator before venturing into the airplane.

A few months later, well after Bill had obtained his rating, I went on a short refresher flight with him and had the pleasure of seeing him expertly handle an almost identical situation. We were approaching the Hartford VORTAC at 6000 feet in a rough cumulus overcast when the radio crackled and Bradley Approach unexpectedly came on with a holding clearance. Victor 3 doglegged at Hartford from the 078° inbound course to the 057° outbound, and we had not received a clearance beyond Hartford. (a situation very similar to figure 7-1). The ride was bumpy inside the clouds, and Bill held a 10° correction against the blustery northwest wind. A rear seat passenger was slightly airsick, and we were anxious to reach Worcester, our destination. The last thing we needed was an en route hold.

"Skylane three four five papa fox, hold northeast of Hartford on the 057° radial, one minute legs, right turns." The DME showed 10 miles from Hartford, which, at 120 knots, meant five minutes. The controller had given us the minimum advance warning specified in his handbook.

"Hold northeast of Hartford on the 057° radial," Bill acknowledged, "one minute legs, right turns, five papa fox." Then, concerned at the lack of an expect further clearance time he prompted, "Say again the EFC time?"

The EFC time gives you an idea of how long you will have to wait, and more importantly, tells you when to leave the hold in the event of communications failure. If your comm radios do quit, ATC expects you to leave the hold at the EFC time.

There was a pause before the controller obliged. "Five papa fox, there will be a thirty minute delay due to traffic. Expect further clearance at 1930."

Bill jotted down the EFC time and groaned at the delay. Glancing at the en route chart he saw that the hold was not published, and so he penciled it onto the chart. It was on our course from the VORTAC and would necessitate, he saw, a parallel entry. Leaving the hold would mean turning outbound in the pattern and re-intercepting the airway. I wondered why ATC had chosen this rather awkward procedure.

As we reached the VORTAC we turned outbound to a 047° heading, keeping the same wind correction. Bill punched his stopwatch for the one minute leg, reset the OBS for the 237° inbound course, and reduced power to the approach speed setting. Later, to

conserve fuel, he would slow the airplane even further. In compliance with AIM procedures he reported, "Three four five papa fox, entered the hold at zero two."

The CDI settled about half scale right, showing the wind correction angle was adequate. During any parallel entry, the first outbound leg is flown on the non-holding side of the course where less protected airspace is reserved for the holding aircraft. At six thousand feet approximately 4.5 nautical miles were reserved for us on the holding side and 2.9 nautical miles on the non-holding side. In general, the protected area is about 50 percent wider on the holding side of the course.

At the end of one minute, Bill turned left again and watched the needle swing left as we crossed the course and return to center as we intercepted inbound. He held a 247° heading to compensate for wind.

Our inbound leg was exactly a minute. Evidently the wind at our altitude was directly on the wing. As we turned outbound, he took up a 037° heading, using the rule that the outbound correction should be double the inbound.

It must have been a textbook wind, because the inbound turn put us exactly on course and once again the 247° heading held the course. It is unusual to get a hold down pat in less than two or three circuits, and Bill must have felt a bit smug. Of course, as he may have privately admitted, it is easier to correct for a direct crosswind than for a quartering one.

With the headings and times under control, Bill decided to reduce the airspeed to save more fuel. The most fuel-efficient airspeed is about 75% of the airplane's best glide speed, or 75% of 80 knots in the Skylane. But at such a slow speed, the nose would be very high, the controls would be mushy and the ride rather uncomfortable. Bill opted to slow only to 80, and gradually reduced power as he raised the nose for the slower speed.

We were fortunately carrying plenty of fuel, so we had no anxiety about a fuel shortage owing to the hold. However, on some closely figured IFR flights, a thirty minute hold could leave a flight dangerously low if there were a missed approach at the destination and a stack of airplanes waiting for an approach at the alternate. In some cases, when the weather is very bad, an airplane would be well advised to decline a hold and divert to another airport if possible.

With the reduced airspeed, the inbound leg was ten seconds too long, but Bill realized that the one-for-one

relationship between inbound and outbound times would return once the airspeed stabilized. On the outbound leg he used the 037° heading for one minute but, to his dismay, saw the CDI swinging to the right as we turned inbound. At the slower speed, larger wind corrections were required.

It took another two circuits to discover that a 15° wind correction worked inbound, with a 25° correction outbound. We orbited the hold five times before receiving our clearance to continue. The ride was bumpy and uncomfortable, and rain drummed on the fuselage. The one small consolation was that our times and angles were accurate so that we painted a consistent, egg shaped pattern on Bradley radar.

Nevertheless, I was relieved when our clearance came, eight minutes before the EFC time. "Cessna three four five papa fox is cleared to the Worcester airport via Victor 3, Whamy, direct." Bill read back the clearance, thanked the man, and we turned on our way.

This story has several elements that the instrument student might keep in mind as a morale booster.

First, in falling into his "spaghetti" pattern during training, Bill was like a great many students. Used to flying VOR to VOR under VFR, where holds and intricate maneuvers solely by instruments aren't part of the picture, he had never had to visualize his airplane's position in such a complex situation. He simply did not have VOR orientation as straight in his mind as he thought he did. Remediating that is, of course, basic to instrument training. Using a simulator and working problem after problem, he quickly learned to interpret the needle — which was par for the course.

Second, holding may be introduced as an unexpected challenge or "pain" in an otherwise routine flight, but that need not daunt you. Especially where the skies are "crowded," holding is part of the routine and can be handled comfortably as such if the pilot knows what he is doing.

Finally, while holding may be a nuisance if you are anxious to get somewhere, it need never be boring — and it won't be if the wind is making its presence felt. As Bill learned during his spaghetti flight, striving for precise holding patterns, and making sure you're correct, is not the mere preoccupation of the pedant but a critical matter of safety. Holding is a device for keeping airplanes separated when they can't see each other. It's the equivalent of a stoplight, and allowing oneself to drift into unprotected airspace is like letting

one's car roll hazardously into a crowded intersection through a red light. Holding patterns can become monotonous, but they are never automatic. Holding: we don't have to love it, but we sure do need it.

## Holding Pattern Terminology

Here are some definitions used in holding pattern work (figure 7-2):

- The **holding fix** can be a VOR, intersection, NDB, OM or DME fix.
- The **outbound turn** is begun at the fix. All turns in a holding pattern are made at standard rate.
- The **holding course** is the course on which the inbound leg is flown. Always fly towards the fix on the course.
- The **inbound leg** is one minute long (one and a half minutes above 14,000 feet MSL), unless otherwise specified in a clearance as a different time interval or a DME distance. The airplane should be *on course* throughout this leg.
- The **outbound leg** is adjusted in length to compensate for the wind so that the inbound leg is one minute long. The outbound heading is also adjusted so that the airplane completes the **inbound turn** just as it intercepts the holding course.
- Abeam** is the position opposite the fix where timing of the outbound leg begins.
- The **holding side** of the course is the side where the hold is accomplished. There is more protected airspace allocated to the hold on the holding side.
- The **non-holding side** is the "other" side of the course. You shouldn't be there.
- A **standard hold** is one in which all turns are to the right.
- In a **non-standard** hold the turns are to the left. Again, all turns are standard rate.
- Maximum legal holding speed** is 175 knots indicated airspeed for propeller driven aircraft. As a practical matter, holding speed is a compromise between minimum fuel burn and acceptable controllability. For training purposes we use our approach level power setting, with gear and flaps up.

## Holding at a VOR

When holding at a VOR, always set the OBS to the *inbound* course. Then, in a standard hold,

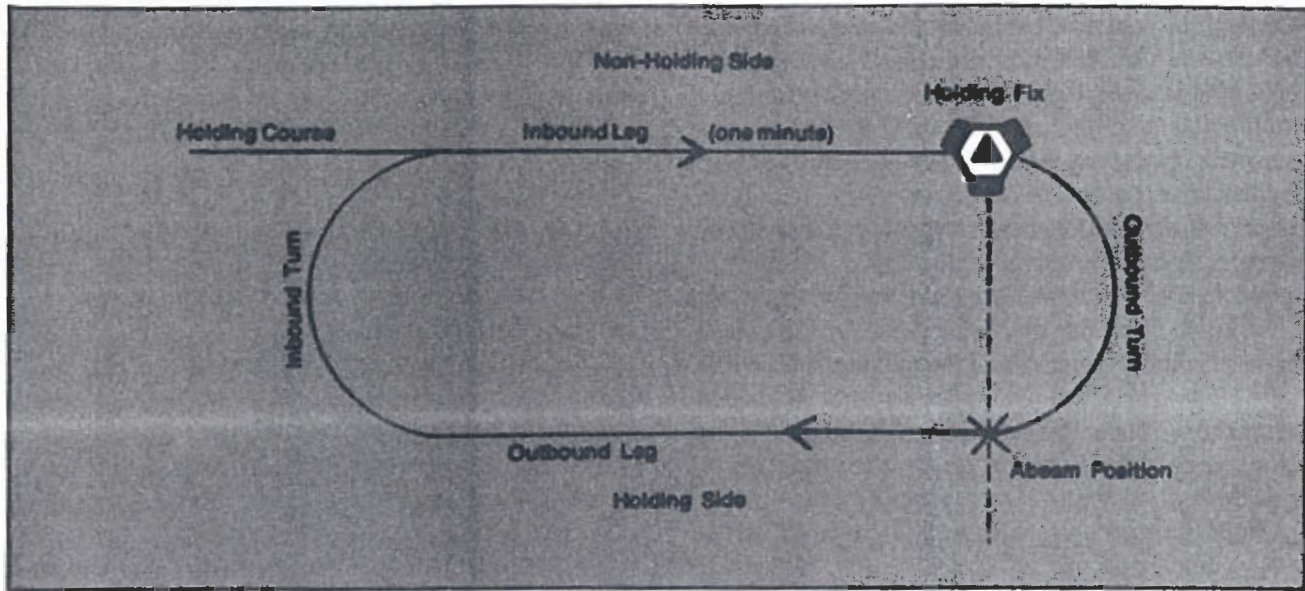


Figure 7-2

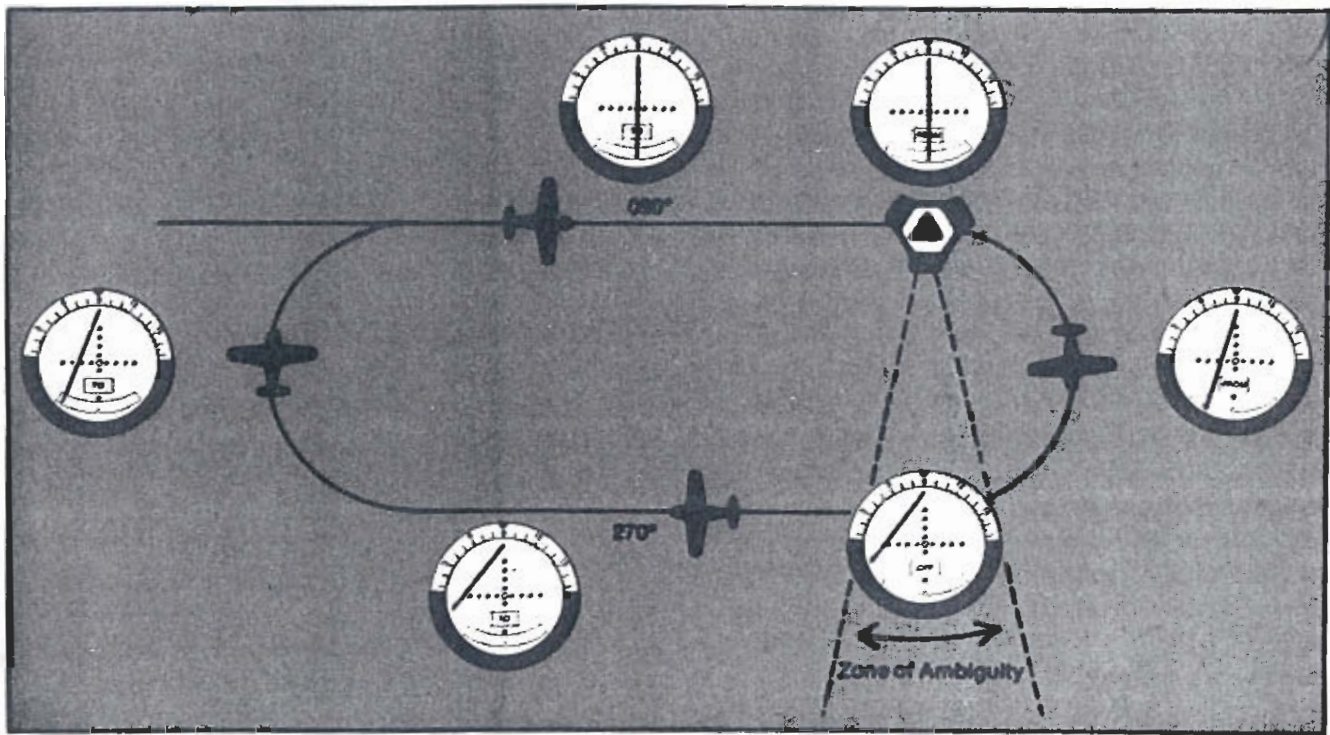


Figure 7-3

the flag and needle indications are as follows (figure 7-3):

*Inbound leg:* TO flag, centered needle.

*Station passage:* The needle may waver as you approach the fix. Don't chase the needle; hold the heading that kept you on course during

the inbound leg. Station passage has occurred when a definite FROM reading is obtained.

*Outbound turn:* During the outbound turn the needle swings to the left.

*Abeam:* The abeam position is the center of the zone of ambiguity. The exact indication

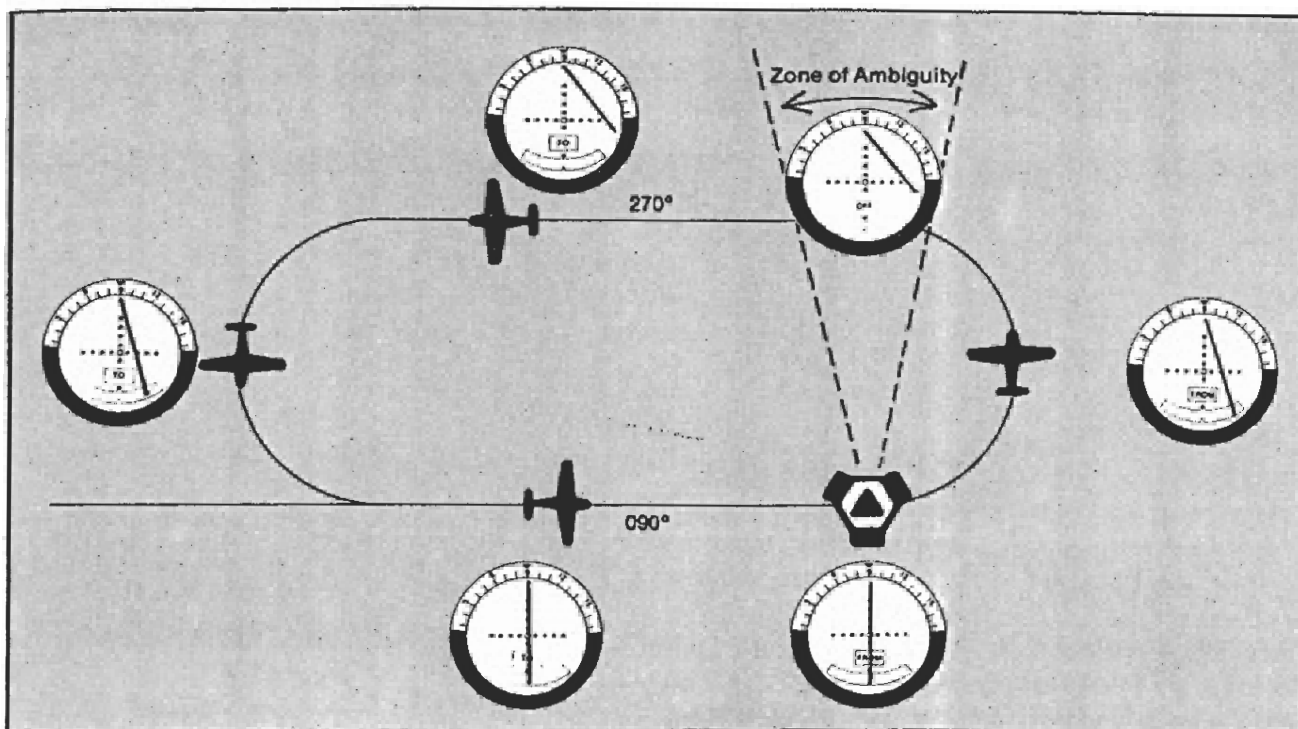


Figure 7-4

must be determined experimentally as it is a characteristic of your particular instrument.

**Outbound leg:** TO indication, full left needle. If the needle moves toward the center, you are flying too close to the inbound course: Adjust your heading to the left.

**Inbound turn:** The needle should swing towards center during this turn, reaching the center just as the heading reaches the inbound course. If you get to within  $30^\circ$  of the inbound heading during the turn and the needle has not left the peg, level the wings and wait for it to move. Resume turning as the needle swings, judging the turn to reach the inbound heading as it centers. If the needle swings early in the turn and crosses center before you reach the heading, you have flown through the inbound course. Continue turning to re-intercept from the non-holding side. Usually a  $20^\circ$  or  $30^\circ$  intercept works well. Adjust the outbound heading as necessary on the next circuit.

In a non-standard holding pattern the needle indications are reversed (figure 7-4).

## Entries

The maneuvering required to enter a holding pattern depends on the direction from which the airplane arrives at the fix. There are three

**The Five T's**  
**Turn**  
**Time**  
**Twist**  
**Throttle**  
**Talk**

Figure 7-5

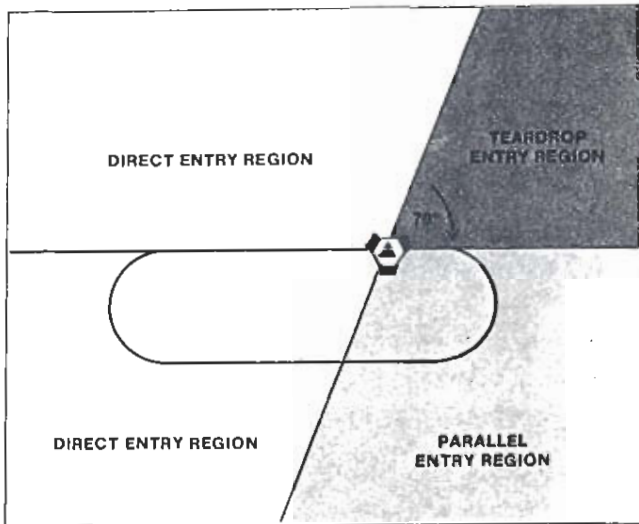


Figure 7-6

basic entry types and each begins with the same basic step: *Fly to the fix*. At the fix, begin the Five T's (figure 7-5). As in procedure turn work, the Five T's greatly simplify the entry process. From there on, the procedure varies depending on the direction of arrival at the fix (figure 7-6). If you arrive from the side of the fix where the holding course lies, a direct entry is called for.

1. The *direct entry* (figure 7-7). Let's assume you approach the fix from the general direction in which the holding course lies. After reaching the fix the steps are:

**Turn** right, at standard rate, to the outbound course (left if it is a non-standard hold);

**Time**. Begin timing one minute when the turn is completed;

**Twist** the OBS to select the *inbound* course;

**Throttle** to slow to holding speed. In a very fast airplane, you may prefer to slow down before reaching the fix, to simplify the entry maneuver. If you receive a holding clearance well in advance, request a speed reduction then and there. You will save fuel by flying more slowly and may use up enough time to eliminate the need for the hold;

**Talk** to report entering the hold.

The airplane is now outbound on the holding side of the course. At the end of one minute:

**Turn** right (left if a non-standard pattern) and intercept the inbound course;

**Time** the inbound leg. The inbound time may be longer than normal on this first circuit, since

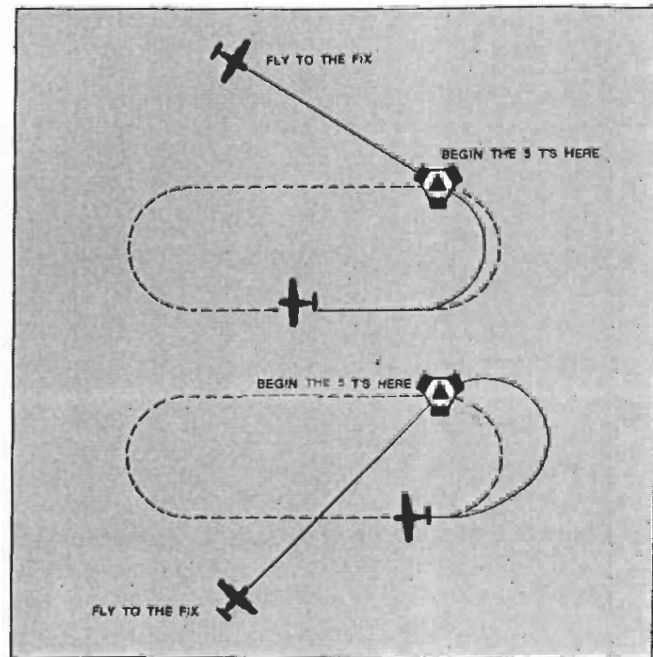


Figure 7-7

you were slowing down on the outbound leg and the average outbound speed was higher than it will be later.

**Twist, throttle, talk:** These steps will not have to be repeated as long as you are in the hold at a constant altitude. However, it is a good idea to say them each time you cross the fix and each time you complete the inbound turn. Part of the work here is to build habits that won't desert you, even in a crisis.

Regardless of the type of entry, the Five T's are used in the same way for each holding pattern entry.

Become proficient at direct entries. Constantly ask yourself questions such as "Which side of the course am I on?" demanding answers such as "holding" or "non-holding," or compass directions, *not* left or right. Pointing to the proper spot on the chart can be used to reinforce visualization. Be sure you realize the significance of needle indications inbound and outbound. Sometimes beginners have trouble remembering whether to dial the inbound or outbound course when entering the hold. They have trouble dialing the inbound as they are turning to the outbound, reciprocal heading. You *always* dial the *inbound* course; there are no exceptions.

The direct entry is usually covered rather quickly. You will practice approaching the fix from several points in the direct entry region, from the holding and non-holding side. In marginal cases, a direct entry can require as much as a  $250^\circ$  turn to the outbound. Of course, in that case, you can choose a parallel entry which would mean only a  $110^\circ$  turn.

2. *The Teardrop Entry.* If you approach the fix from the opposite side and on the non-holding side, an immediate turn to the outbound course would put you too close to the holding course, so that on turning inbound, you would fly through it and have to re-intercept from the non-holding side (figure 7-8). To avoid this problem, make the initial turn to a heading  $30^\circ$  towards the holding side.

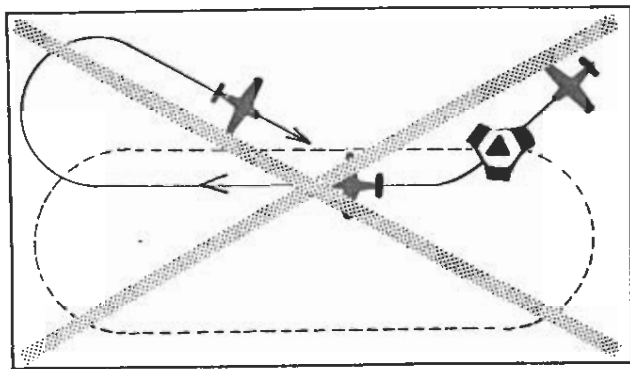


Figure 7-8

To determine the proper teardrop heading, note which side of the course the holding pattern is on, using one of the eight cardinal points. Then just turn to a heading  $30^\circ$  from the outbound course in that direction. For example, if you want to hold on the  $270^\circ$  radial with right turns, the holding pattern is south of the holding course. Therefore the teardrop heading is  $30^\circ$  south of  $270^\circ$ , or  $240^\circ$ . Determine and turn to this heading mechanically, by looking at the DG. Do not use mental arithmetic.

At the end of one minute, turn inbound and intercept the inbound course (figure 7-9). If the initial outbound leg of a teardrop entry is extended beyond one minute, you will find yourself too far from the inbound course. Watch the VOR needle during the inbound turn, and if

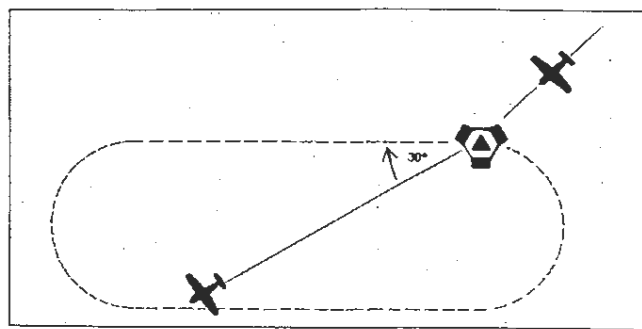


Figure 7-9

you get within  $30^\circ$  of the inbound heading before the needle leaves the peg, roll level until the needle moves. Then continue the turn to intercept as it centers. Consciousness of the needle during the turn is part of correct visualization.

3. *The Parallel Entry.* If you approach the fix from the opposite side, and on the holding side, turn left (right for a non-standard pattern) to the outbound course after you cross the fix. Hold this heading, paralleling the outbound course on the non-holding side. After one minute, turn left (for a standard hold) again, cross the course and re-intercept from the holding side. A good intercept angle is given by a heading  $30^\circ$  past the inbound course (figure 7-10).

In making a parallel entry, do not track outbound on the holding course; parallel it on the non-holding side. The CDI should be deflected to the right in a standard hold at a VOR. When you turn inbound, the CDI should cross to the left side. Do not fly direct to the VOR. Use a  $30^\circ$  intercept heading to get on course before reaching the station.

## Compensating For The Wind

With few airplanes on his scope, the approach controller was relaxed and chatty. His vector to the airport had included a hefty wind correction, but we reported turning another 10 degrees into the wind. "Skyhawk four five nine one golf" he said, "you evidently see the airport, report right downwind for Runway 33."

My student, who had a quick wit, answered him: "Roger, Approach, nine one golf can land on 33 but it would be just as easy to back it in to Runway 15."

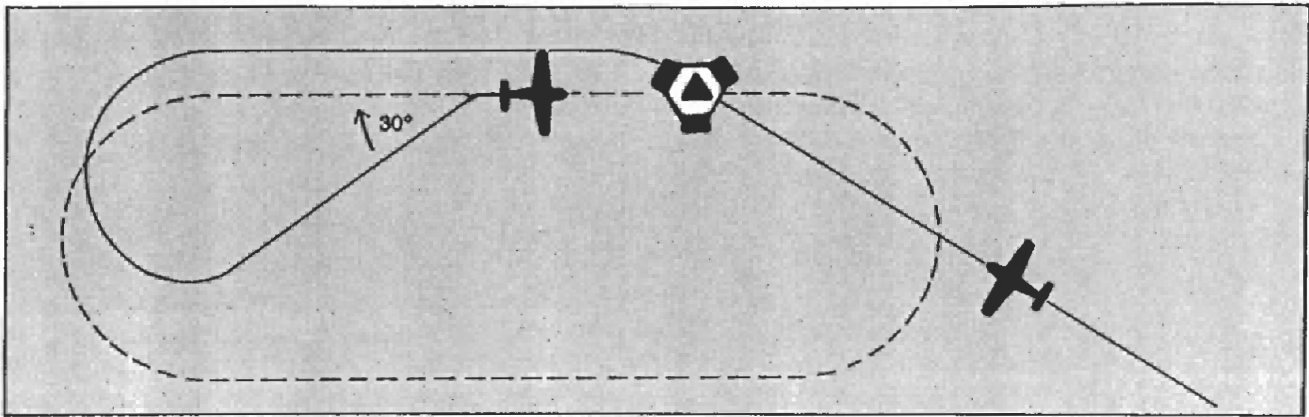


Figure 7-10

The controller laughed as he told us, "Sorry, nine one golf, 33 is the active runway. Contact the tower now, 119.6."

It was one of those cold blustery winter days with a strong northwest wind and noticeable turbulence to about 3000 feet. Our compensation for the strong wind and bumpiness was the virtually unlimited visibility.

We had practiced holding at a VOR and flying conditions were, to say the least, interesting. The published hold was southeast of the station with the inbound leg heading northwest, directly into the wind. It blew so strongly that we had been unable to achieve the standard one minute inbound leg length. Even by eliminating the outbound leg completely and making a 360° turn inbound as soon as we reached the VOR, our inbound segment was an excessive three minutes. Holding northwest of the fix had proved possible but difficult, requiring a *six minute* outbound leg to lengthen the inbound segment to one minute.

The wind at our altitude must have been nearly 50 knots, and, on the way back to the airport, we slowed the airplane to minimum controllable airspeed. Pointed into the wind, we had the interesting experience of observing a zero groundspeed. It is not often you get to "hover" in a Skyhawk.

Wind effect on an airplane is often confusing, even to experienced pilots, and even the difference between airspeed and groundspeed can be a particularly difficult concept.

We can think of the air we fly in as an ocean that may or may not be moving with respect to

the ground. Currents within the air mass affect the airplane's position over the ground, but not its airspeed or position in relation to other airborne objects.

*Wind* is movement of the air mass in relation to the ground, and the airplane knows nothing about movement over the ground. Except that windy days are frequently more turbulent, we notice no difference in performance or safety in flight between windy and calm days. We hesitate to fly in high winds only because of the difficulty of taxiing, taking off and landing.

An analogy can be drawn between an airplane flying in a moving air mass and a motor boat navigating in a current. Imagine the boat on a river with a current equal to the boat's own speed. Headed upstream, the boat will not move relative to the riverbank, while headed downstream, it will appear to zoom along at twice its normal rate. The upstream case is analogous to our Skyhawk in slow flight bucking a 50 knot headwind.

Pointed upstream or downstream, the boat is using the same power and is moving at the same "water speed." Only if it has a destination and a schedule will its "groundspeed" be important. If it touches the riverbank its direction of travel will be critical. Angled upstream it will contact the shore softly, angled downstream it will crash while going at double its normal speed, illustrating why we prefer to land into the wind.

Here is a more complex illustration of the effects of the wind. Assume the wind is out of the west. An aircraft flies over the airport and releases a balloon with just enough bouyancy to

exactly hold altitude. The aircraft then flies north for 15 minutes, makes a 180° turn and flies south for fifteen minutes. Where is the aircraft and where is the balloon?

The balloon and the aircraft are both suspended within the same air mass. Since the aircraft flew directly away from the balloon and then directly back towards it, the two are both over the same spot. Since the air mass is moving over the ground from the west, both are east of the airport.

So far, we have talked primarily about the effect of the wind on aircraft performance and position *within the air mass*. But the wind also has a very important effect on our cross country flying.

A variant of Murphy's Law states that "the wind is always against you." Although we have all occasionally enjoyed the exhilaration of a monstrous tailwind, over a lifetime of flying cross country, the net effect of the wind will be to slow you down. Assuming you will have headwinds and tailwinds over equal numbers of miles, you will fly many more hours with the wind on the nose.

Imagine a round trip from "point A" to "point B" and return. The distance is 100 nautical miles and your airspeed is 100 knots. In the absence of wind, the 200 mile trip would take two hours.

Now suppose there is a 20 knot wind blowing from "A" to "B". Your groundspeed on the leg from "A" to "B" is 120 knots, so you complete the 100 mile trip in 50 minutes. On the

return leg your groundspeed is only 80 knots, so the trip takes one hour and 15 minutes, for a total flight time of two hours and five minutes! The wind has more time to work against you as a headwind than to help you as a tailwind.

Most winds are not directly on the nose or the tail but at some angle to the route of flight. If it comes from the half circle behind us, we are thankful for the extra groundspeed; if it comes from in front, we shake our heads and mutter. And with good reason, because a crosswind from ahead of the wingtip slows us down *more* than a quartering tailwind of the same magnitude and angle to the course speeds us up. (Get out your computer if you don't believe this.)

The explanation is that a certain *percentage of your groundspeed* is lost in counteracting the crosswind component to keep you on course. With a quartering tailwind, the groundspeed is higher to begin with, so more knots are lost in maintaining the crab.

A direct crosswind reduces groundspeed because some thrust must be used to crab into the wind. In fact, even a wind slightly behind the wing will have a negative effect on forward groundspeed if it is strong enough in relation to the airspeed.

But back to holds. If the wind is parallel to the holding course, either inbound or outbound, it is merely necessary to adjust the length of the outbound leg to achieve an inbound leg of exactly one minute. This is done by timing both the inbound and outbound legs and making pro-

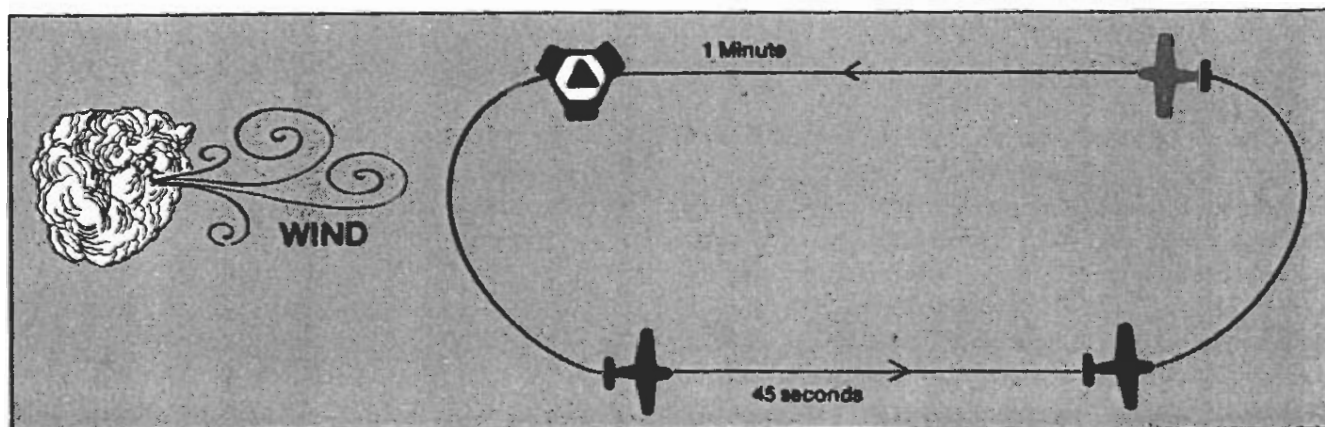


Figure 7-11

gressive adjustments until the correct outbound time is determined (figure 7-11).

If there is a direct crosswind, it is necessary to determine the wind correction angle to stay on course inbound. The outbound heading adjustment will be approximately *double* the inbound correction (figure 7-12).

This is another instance where thinking in terms of compass directions is much simpler than using "left" and "right." The inbound and outbound wind corrections will both be to the same compass direction, to the north for example. However, if the inbound correction is to the *left*, the outbound correction will be to the *right*, and vice versa. Since "left" means a smaller numeric heading and "right" means a greater numeric heading, you will soon be involved in mental arithmetic — something to be avoided in the cockpit. Compass directions are much more expedient.

Naturally, in most real life holding situations, there will be a headwind or tailwind *and* a crosswind component, so the pilot will have to determine the proper outbound time and proper

wind correction angles, inbound and outbound. On a fairly windy day, it is reasonable to take three or four turns in the hold to become properly established.

## The Holding Clearance

While most holding patterns that you will be assigned are published on a chart or approach plate, occasionally you will receive an unpublished hold, and it is necessary to extract the information you need from the holding clearance. The clearance has a specific format:

1. The word **hold**;
2. A **direction** you are expected to hold from the fix;
3. The name of the fix;
4. A **course**;
5. **Leg length**, in minutes or miles;
6. The **direction** of the turns; if not stated, assume right turns;
7. Expect **further clearance (EFC)** time. This tells you when to leave the holding pattern if you lose communication capability while in the hold and allows you to evaluate your

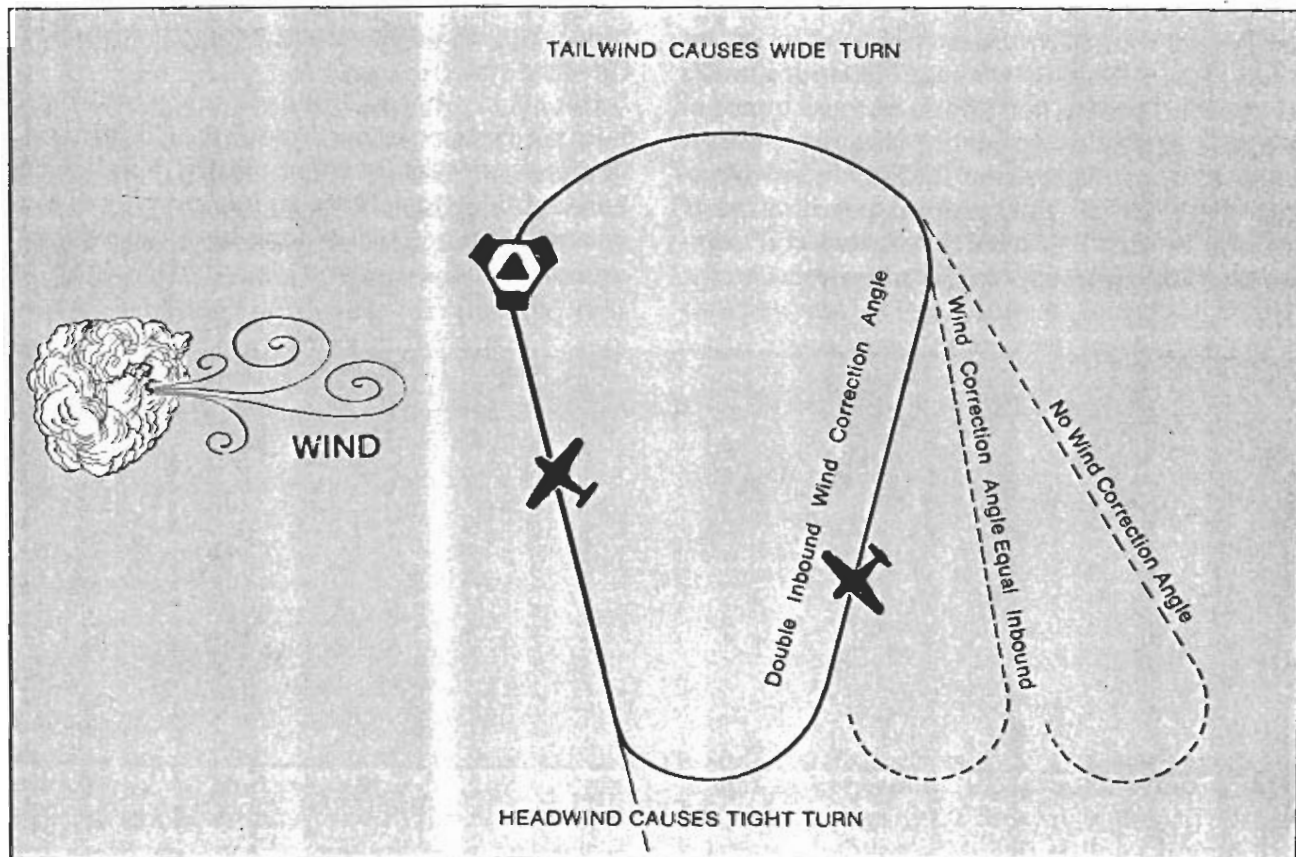


Figure 7-12

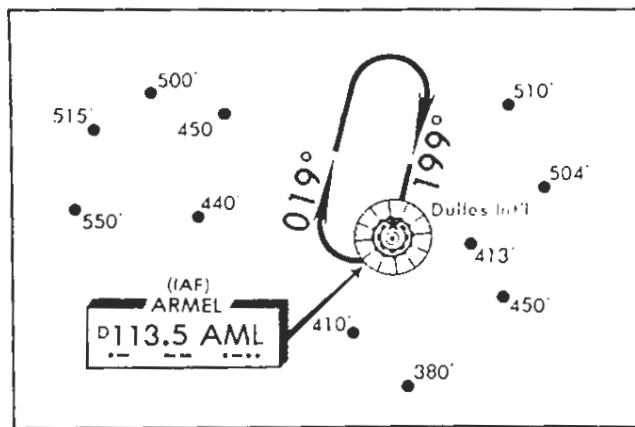


Figure 7-13

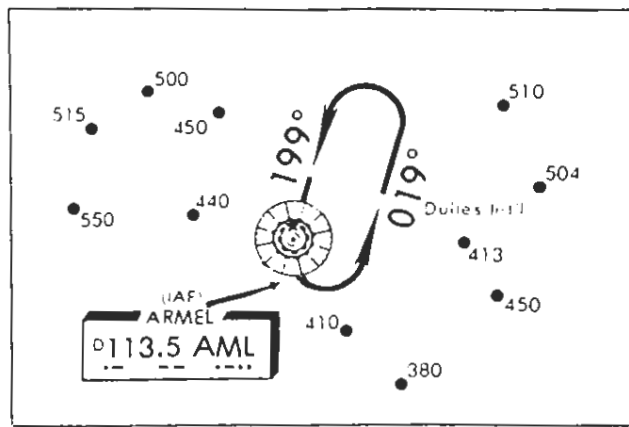


Figure 7-14

fuel situation. In the event of lost communications, leave the hold at the EFC time.

An example of a holding clearance, with the specified pattern shown in figure 7-13: "Hold north of Armel on the 019° radial, one minute legs, expect further clearance at 1700." (Times are given in UTC.)

Notice that the direction specifies the side of the fix where the course lies and is actually redundant. It is included in the clearance for emphasis to make sure no pilot mistakenly holds on the wrong side of the fix. It does not concern which side of the holding course is the holding side; that is determined by the direction of turn. The clearance for a hold at Armel on the other side of the same course would be given as follows: "Hold north of Armel on the 019° radial, left turns, one minute legs, expect further clearance at 1700" (figure 7-14).

Since timing the hold legs adds to your mental chores, a leg length in miles simplifies the holding procedure. When issued an en route holding clearance, you may request the privilege of flying an inbound leg that is a distance, rather than a time (assuming you are DME equipped, of course).

To properly interpret and comply with spoken holding clearances a definite procedure is helpful. Here is a suggested method:

- a. Draw the fix.
- b. Draw the course, with an arrow pointing inbound to the fix.
- c. Draw the direction of turn.
- d. Indicate the airplane's position in relation to the fix and visualize the entry. If a teardrop entry is required, determine the initial heading.

Consider this example: the aircraft is south of

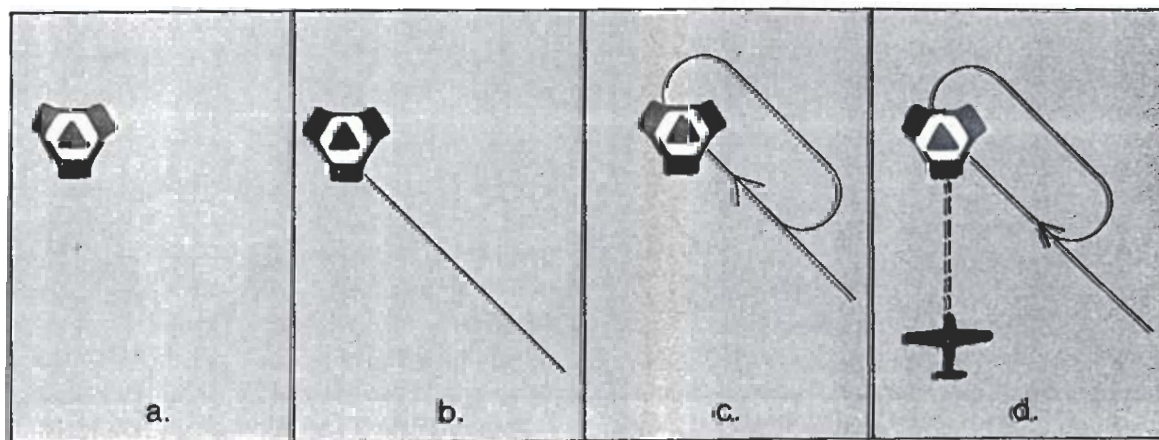


Figure 7-15

the VOR. Your clearance is: "Hold southeast of the VOR on the 130° radial, one minute legs, EFC at 1730." This clearance calls for a direct entry (figure 7-15).

### Holding At Other Types of Fixes

If the holding fix is an intersection, some peculiarities distinguish the procedure from a hold at a VOR.

As at a VOR, the OBS should be set to the inbound course; that is, the inbound course *to the intersection*. In some cases, the inbound course to the intersection will be the outbound course from the VOR, so that the number one VOR instrument will have a FROM indication throughout the hold. Since you never cross the VOR, the flag indication will be the same throughout the holding pattern.

Unless the radials defining the intersection are nearly at right angles, there is no reliable way to determine the abeam position. Therefore, the outbound timing is begun when you

roll wings level on the outbound heading (figure 7-16).

Because of the distance from the VOR, the outbound needle indication may not be a full-scale deflection. Remember, a full-scale deflection means at least 10° off course.

With dual omnis, intersection holding is not complicated. However, with only one, you must switch back and forth between the two stations several times, since you use one station for course guidance and the other to determine station passage. In this case, requesting two minute legs will lighten your workload. Even better alternatives are requesting a leg length in miles, if you are DME equipped, a hold at a station instead of the intersection, or a sequence of vectors instead of a hold. When you have had an equipment failure, ATC will provide help, if you ask for it.

If you are holding at an intersection with only one omni, a common error is switching radios too frequently. Once you have determined your

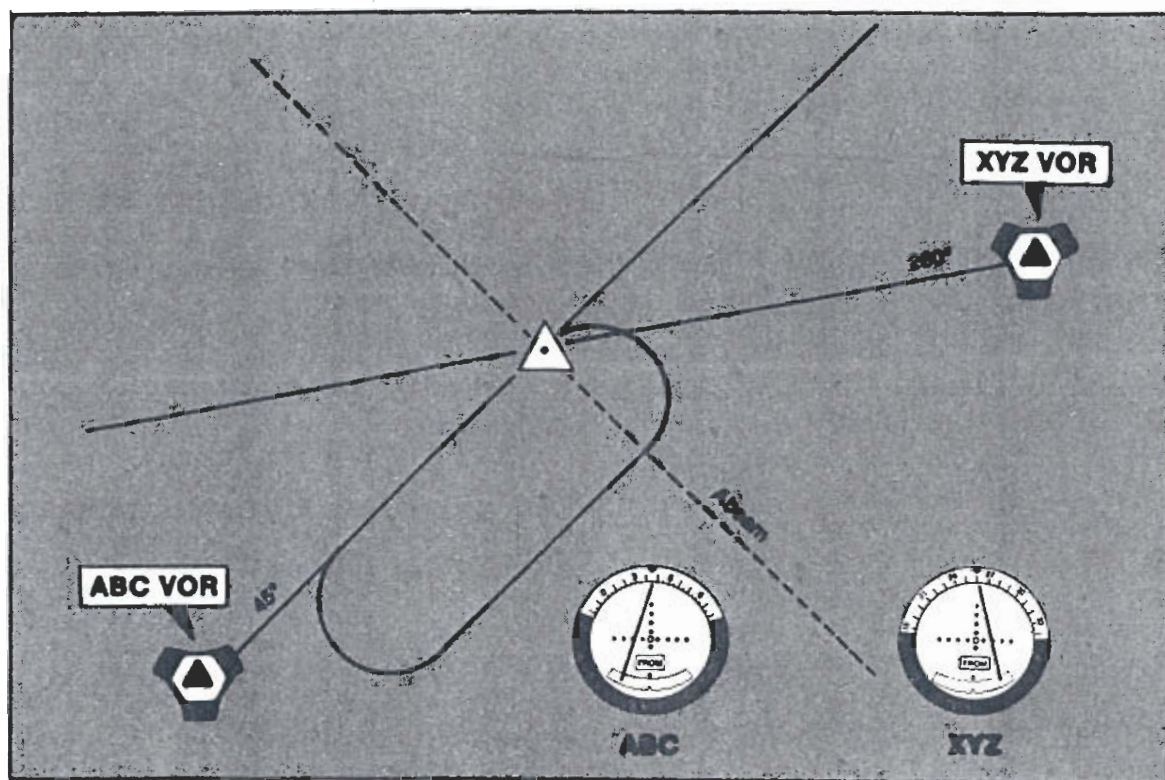


Figure 7-16

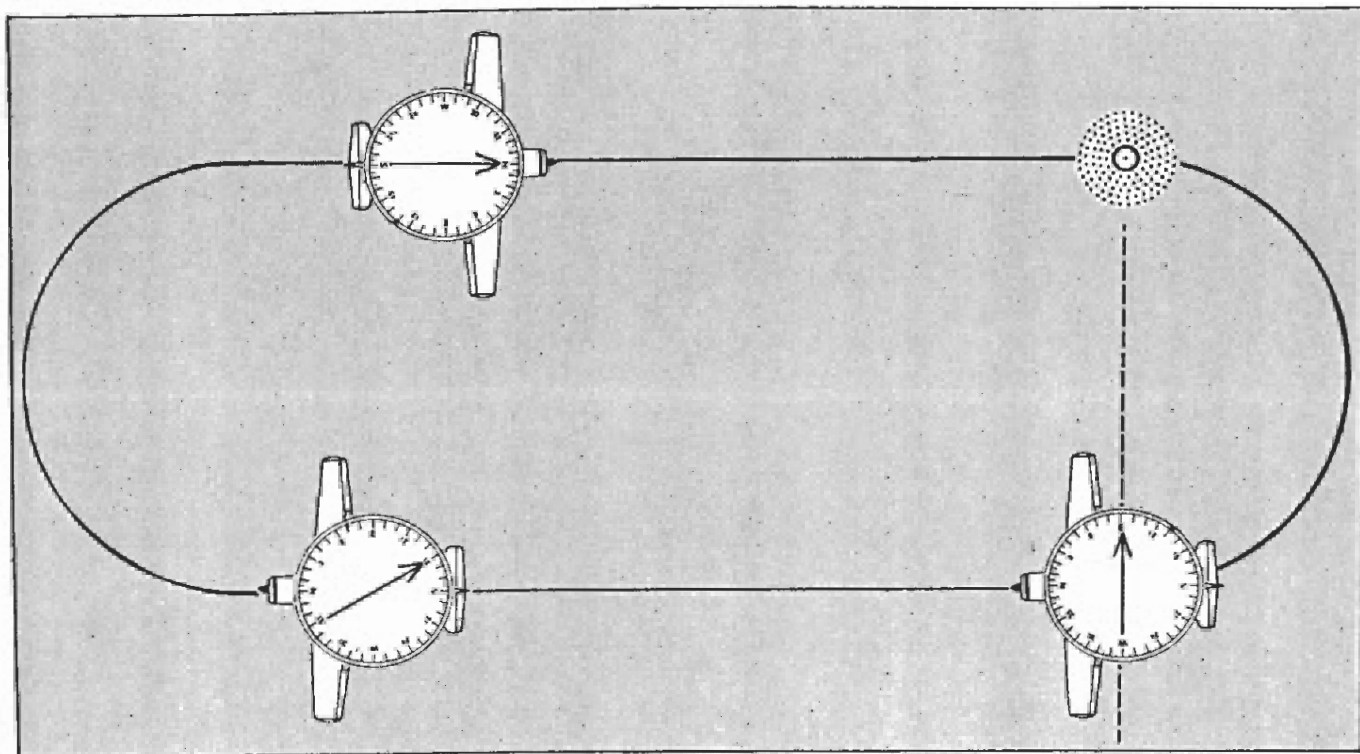


Figure 7-17

inbound reference heading, you can select the cross radial station while awaiting station passage and rely on heading control to keep you on course. Too frequent switching easily leads to confusion. Remember, each time you switch, you must change frequencies *and* OBS settings. It is all too easy to select the wrong OBS setting with the right frequency.

When holding at an NDB (figure 7-17), you have certain instrument indications to rely on.

**Inbound leg:** Track to the station as you normally track an NDB bearing.

**Station passage:** This is considered to occur when the swinging needle passes either wing. The faster the needle swings, the closer the flight path was to the station.

**Outbound turn:** During the outbound turn, the needle swings to the rear of the airplane and then moves back towards the front as the turn is completed, usually stopping somewhere in front of the wing.

**Abeam:** The abeam position is reached when the airplane is on the outbound heading and the needle is off the wing. Note that ADF indications are unreliable when the airplane is

banked, because the bank angle of the loop antenna adds a component to the bearing from the airplane to the station. Look at the indicator after the wings are level, then adjust as necessary.

**Outbound leg:** The needle swings to the right, towards the rear of the airplane. In "no-wind conditions", the needle is approximately 30° off the tail at the end of the outbound leg.

**Inbound turn:** As the heading approaches the inbound course, the needle swings towards the nose. If the DG and ADF reach the tops of their respective cards simultaneously, you will roll out exactly on course. If, after the wings are level, the needle is not on the nose, make a turn to intercept and track the inbound bearing normally (figures 7-18 and 7-19).

**The Teardrop Entry:** Cross the fix and choose the teardrop heading as in a hold at a VOR. The needle will initially be on the tail. The needle is on the tail any time you fly directly away from an NDB (figure 7-20).

**The Parallel Entry:** After initially crossing the fix, you will be on the non-holding side. The

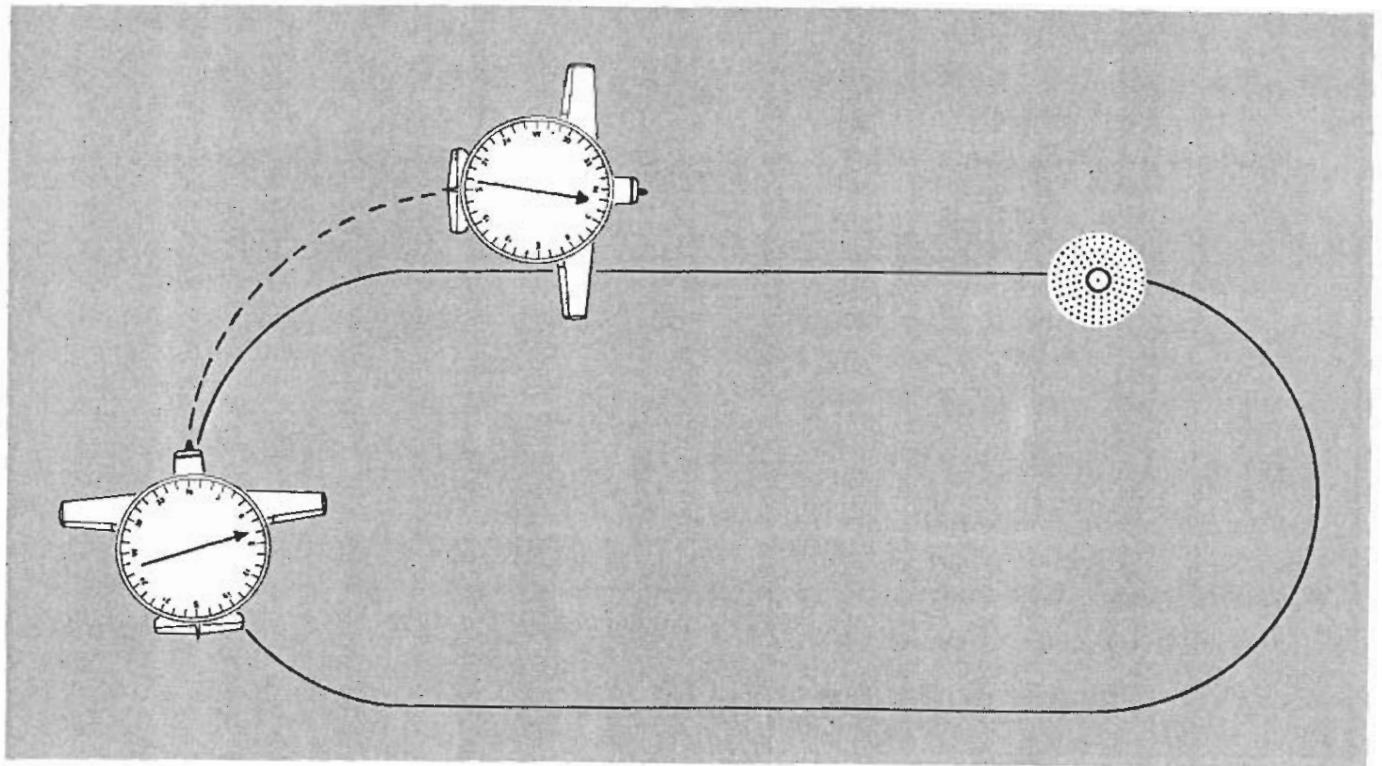


Figure 7-18

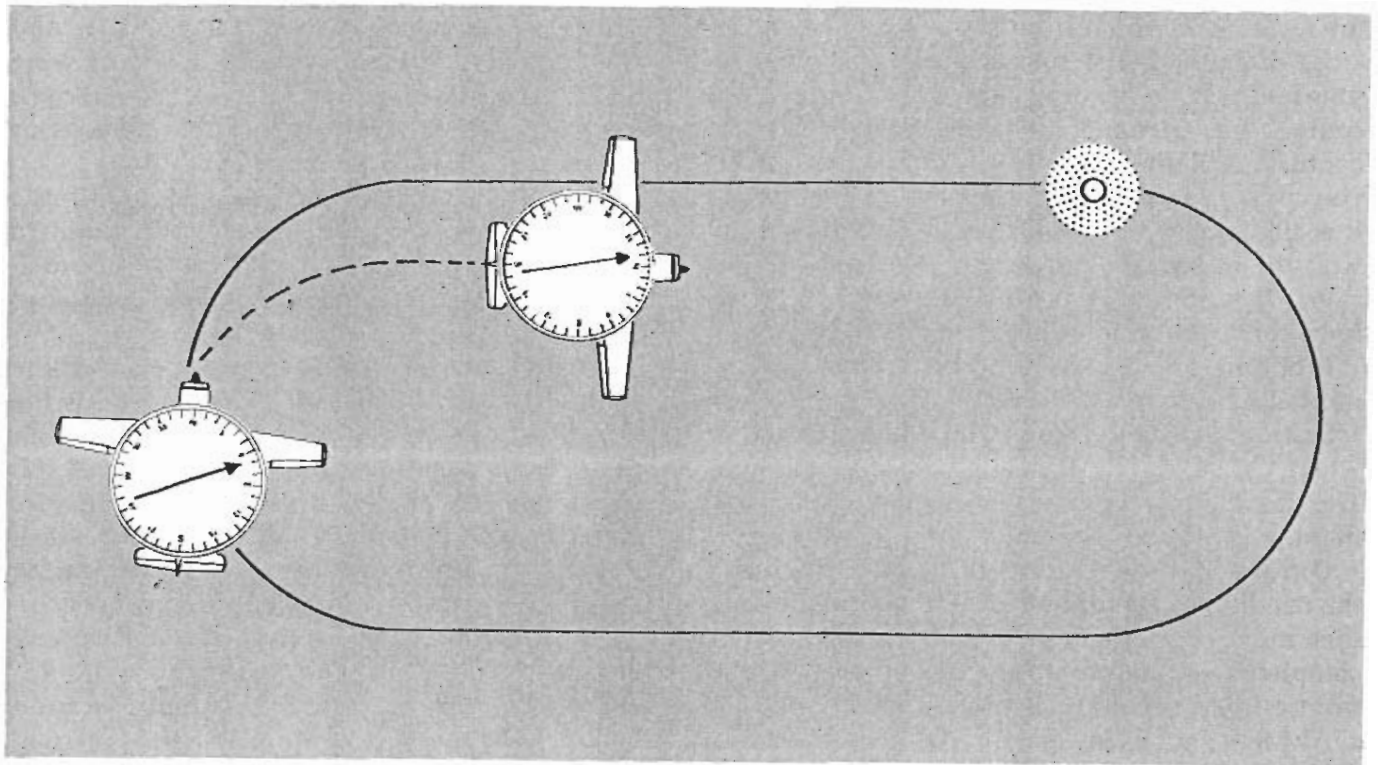


Figure 7-19

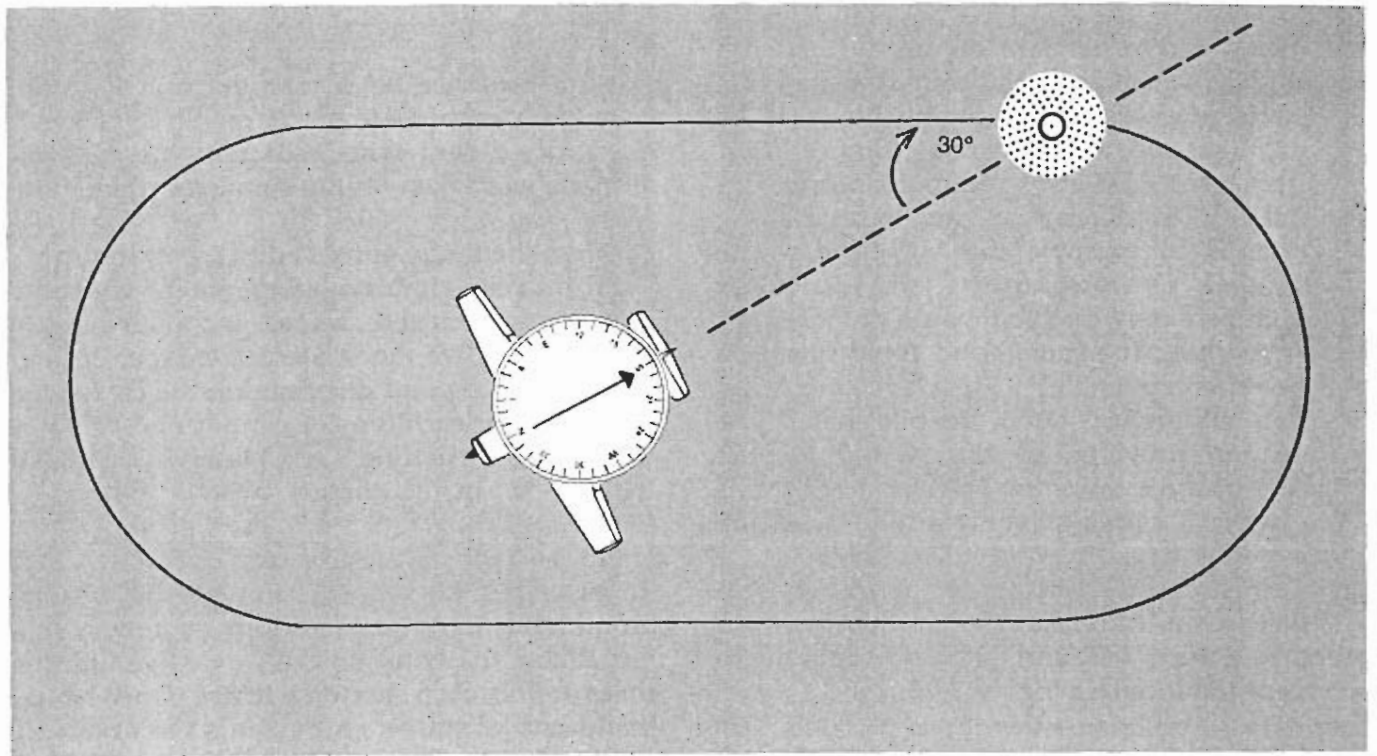


Figure 7-20

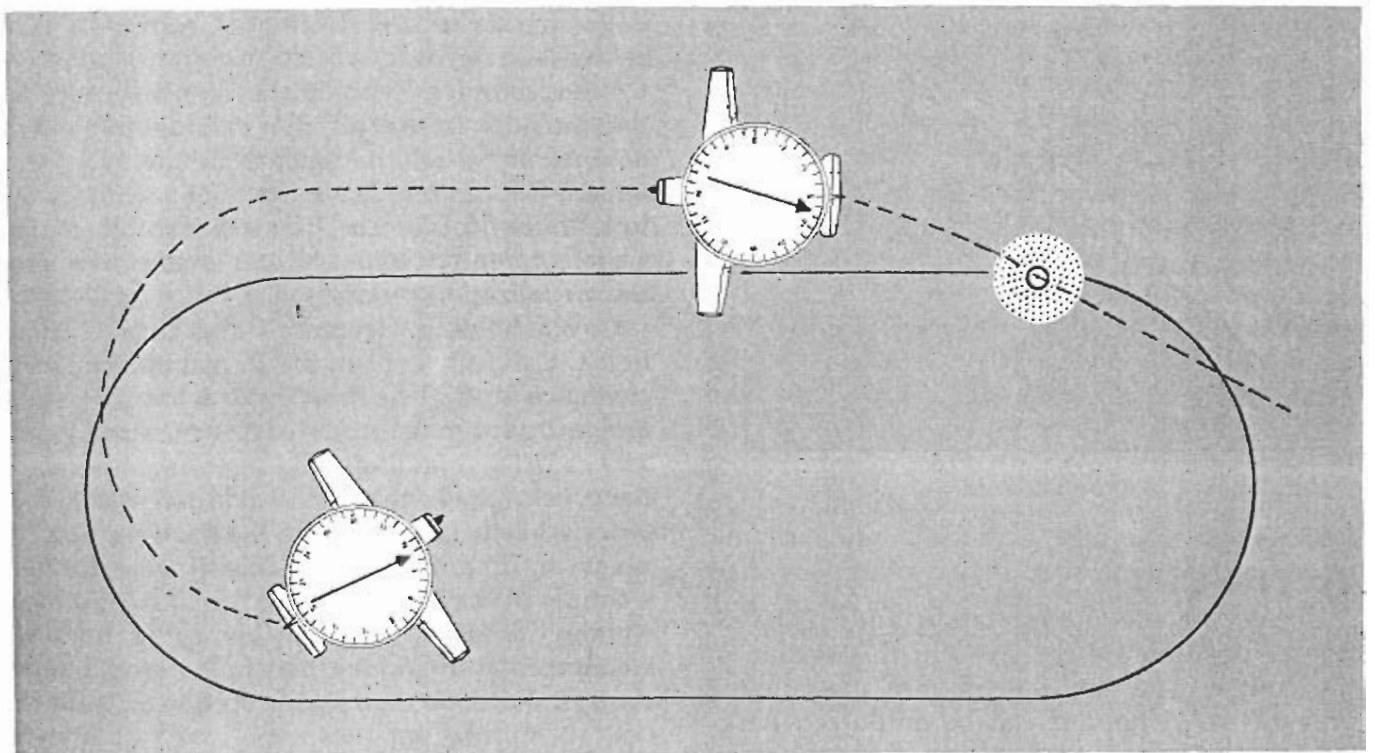


Figure 7-21

needle will be to the left of the tail (to the right of the tail in a non-standard hold). As you turn inbound, you will cross the course. Establish a 30° intercept angle by continuing the turn 30° beyond the inbound heading (figure 7-21). Notice that the ADF gives you more information than the VOR display in the corresponding situation. If, for example, the ADF needle were on the nose, or worse, to the left, you would know immediately that you would not intercept before reaching the station and could turn to a sharper intercept angle.

When holding at a LOM, the pilot has all the information provided by the NDB, plus the accuracy of the localizer on the inbound course. However, if there is no compass locator at the outer marker site, a hold is still possible.

Simply turn outbound when the marker beacon is received, start timing when the wings are level, and turn inbound after one minute to intercept the localizer (figure 7-22).

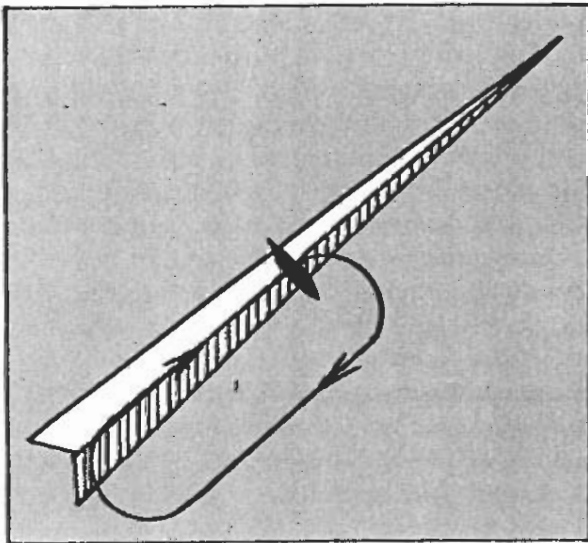


Figure 7-22

## To The CFII

Correct needle interpretation and visualization of position are the goals of this section of the course. The same techniques used in the previous two chapters can be employed here. Repeatedly verify that your student knows where he is (compass directions or holding/non-holding side, *not* left and right) and that his

attention is focused on the proper instrument. A surprisingly common student error is losing track of whether he is inbound or outbound. Constantly emphasize use of the Five T's. Once again, a student who becomes "lost" in the airplane was taken off the simulator prematurely.

When the direct entry is down pat, introduce wind into the simulator. Experiment with various winds parallel to, across, and at an angle to the course. Give the student the experience of timing each leg and determining the crosswind correction for each type of wind. Concentrate at this stage on getting each pattern down pat, making as many circuits of the pattern as necessary.

Progress to the teardrop and parallel entries. Position the student in one of the regions around the fix, and have him fly towards it, visualizing the entry on the way. Give him ten miles at first, then shorten it to five. Once he has made several correct entries, it is not necessary to actually fly each one. As soon as he announces the correct entry, move him to another spot and start again. The simulator is a tremendous time saver here. Remember, correct visualization is the goal.

We recommend visualization for determining the entry, because all the various tricks for determining it rely on mechanical memory aids which, if forgotten, leave the pilot with no way to tell what to do. The best aid is to have him sketch the entry on his chart or kneepad to help the visualization process.

Cover holding clearances and unpublished holds. Carefully explain the format of a holding clearance so that he will know what to expect and will recognize if one part is missing. Read him official-sounding holding clearances and have him draw the hold and determine the entry while he is en route to the fix. Give him 10 miles at first, then five. This is yet another example of the power of the simulator to reduce training time. Thorough coverage of holding clearances and unpublished holds would take days in the airplane; you can do it in an hour or two on the simulator.

Having argued against mechanical aids, I now offer one for your instructional use. When you

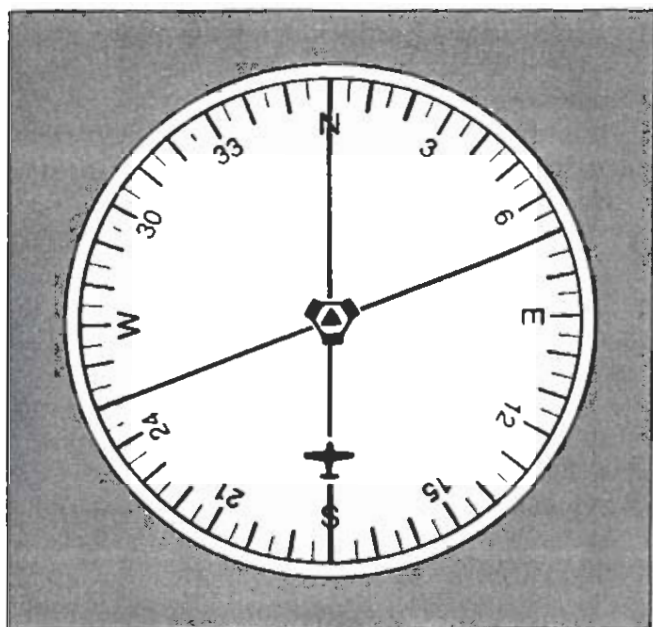


Figure 7-23

want to assign a teardrop entry, say, you may be interested in the following gimmick to quickly determine the proper holding clearance. First, clear him direct to the fix, and when he is on his heading, look at the DG (figure 7-23). Imagine two lines crossed on the face of the dial as shown, the fix at the center and the airplane at the bottom of the DG. Then any standard hold on a radial in the upper right segment of the gauge will need a teardrop entry. Likewise the upper left contains all the standard holds with parallel entries, and the two bottom segments contain all the direct entries. For a non-standard hold, the diagonal line rises the other way (figure 7-24).

Cover intersection holds. In clearing the student to an intersection, have him intercept one of the radials from an unknown position and determine for himself whether to turn towards or away from the VOR. This reinforces previous orientation work.

Once he is en route to the intersection on a radial, his entry determination is easier than at a VOR. At a VOR, there are 720 possible holding patterns (a standard and non-standard pattern on each radial), but at an intersection of two courses, there are only eight. In real life, the hold is usually on the radial on which he approaches the fix, either a simple direct entry or

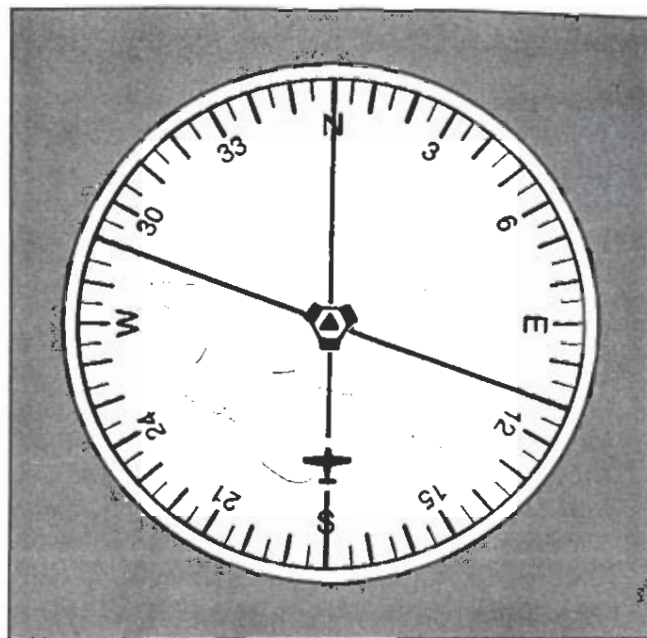


Figure 7-24

his choice of teardrop or parallel. Most pilots prefer teardrop over parallel, because it gets them on course farther from the fix.

In training, you may also give him some intersection holds on the crossing radial to stretch his visualization abilities.

If the simulator has only one VOR display, all intersection work is done in an equipment failure mode, i.e. as though his second VOR had failed. Explain carefully the difference between dual and single omni intersection holds. A common error in single omni work is to switch back and forth between stations too frequently. Demonstrate that once he knows his reference heading, he will stay on course by holding it. This is especially true if the intersection is far from the station. In that case, it is more important to accurately notice passage of the crossing radial.

In covering ADF holds, emphasize the expected needle indication at each point in the procedure. In the real world, unpublished ADF holds are rare. However, mention that if he does receive a clearance for an unpublished ADF hold, he must be sure to notice whether the stated course is an inbound or outbound bearing.