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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

INSTRUMENT REFRESHER COURSE
PRECOURSE WORKBOOK

MAJOR DAVID R. VANDENBURG 85-2765

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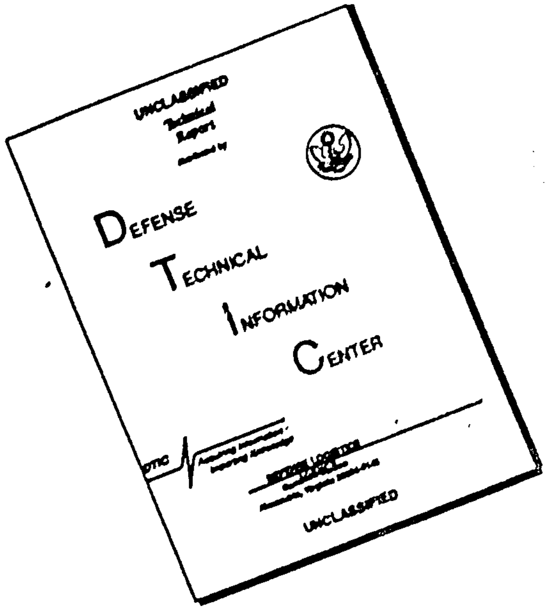

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Air Force pilots attend an Instrument Refresher Course (IRC) yearly to review instrument procedures and learn new techniques of instrument flying. Instructors are often forced to spend too much time reviewing basic procedures and are thus unable to cover recent advances in instrument flying. This workbook is designed to be a review of selected basic instrument flight procedures to enable pilots to refresh their knowledge prior to class. It is organized by subject and includes learning objectives, review material, and a selection of exercises to allow pilots to assess their knowledge in the areas reviewed.

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PREFACE

This workbook is designed to provide SAC pilots with a review of selected instrument flight subject areas for use prior to attendance at the Instrument Refresher Course (IRC). It was developed because there is no single source document for this type of review and course Instructors were spending a large amount of class time reviewing basics instead of teaching new techniques. The text is organized by subject and includes lesson objectives, a basic review of the subject, and a series of questions or problems related to the subject. The subjects were selected by the author based on weak areas noted while teaching the Instrument Refresher Course. Also included is a listing of references and related sources for further review if desired.

The workbook is designed to be used in a manner that is most useful to the pilot. For example, if pilots feel they already have a good working knowledge of a subject, they may wish to skip the review material and accomplish the exercises. If a pilot has trouble with a problem, the review material is available for reference.

The book will do no good if it is not used! Pilots attending the Instrument Refresher Course must take the time to accomplish the exercises and evaluate their knowledge in these areas. Doing so will save time during the class portion as the instructor will not have to discuss basic material.

This guide was compiled using the references listed in the bibliography and is not intended to conflict with the flight manual or any other directive. If a conflict should arise, the flight manual or directive will be followed. The workbook is written to be published as a precourse workbook after review by the sponsor.

ABOUT THE AUTHOR

MAJOR DAVID R. VANDENBURG

Major VanDenburg received his Bachelor of Science degree in Mechanical Engineering from Michigan State University in 1970. He was commissioned through the Air Force Officer Training School and earned his wings at Laredo AFB, Texas in 1972.

He is a B-52 instructor pilot with extensive experience in operations and training. Following B-52 Initial Qualification training, he was assigned to the 340th Bombardment Squadron, Blytheville AFB, Arkansas. From Blytheville AFB he was deployed to Andersen AFB, Guam in support of Linebacker II. After this deployment and while stationed at Blytheville AFB, he earned a Master of Science degree in Systems Management from the University of Arkansas.

In 1978, he attended the Air Force Institute of Technology (AFIT) at Wright-Patterson AFB, Ohio, where he earned a second Master of Science degree in Logistics Management. This degree led to a rated supplement position in aircraft maintenance at Wurtsmith AFB, Michigan. While there, he served as the Logistics Plans Officer, Job Control Officer, Maintenance Control Officer, and the OMS Maintenance Supervisor. In 1981, he was transfered to the 524th Bombardment Squadron, Wurtsmith AFB, where he served as a squadron instructor pilot, Flight Commander, and Training Flight Instructor Pilot. He is also a graduate of SAC's Instrument Flight Instructor Course (SIFC).

Major VanDenburg is a Senior Pilot with approximately 2500 hours of flying time and 12 years of experience in SAC. He attended Squadron Officers School in 1976 and Air Command and Staff College in 1985.

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Chapter One

CPU-26A/P DEAD RECKONING COMPUTER

OBJECTIVES

At the completion of this lesson the pilot will:

1. Given present position and ground speed, be able to use the CPU-26A/P computer to determine the appropriate heading, distance, and estimated time enroute (ETE) to a desired TACAN fix.
2. Be able to set up the CPU-26A/P computer to solve ratio type problems involving fuel flow, ground speed, and time.
3. Be able to use the CPU-26A/P computer to determine climb and descent gradients.
4. Be able to use the CPU-26A/P computer to determine Visual Descent Points (VDP) for nonprecision approaches.

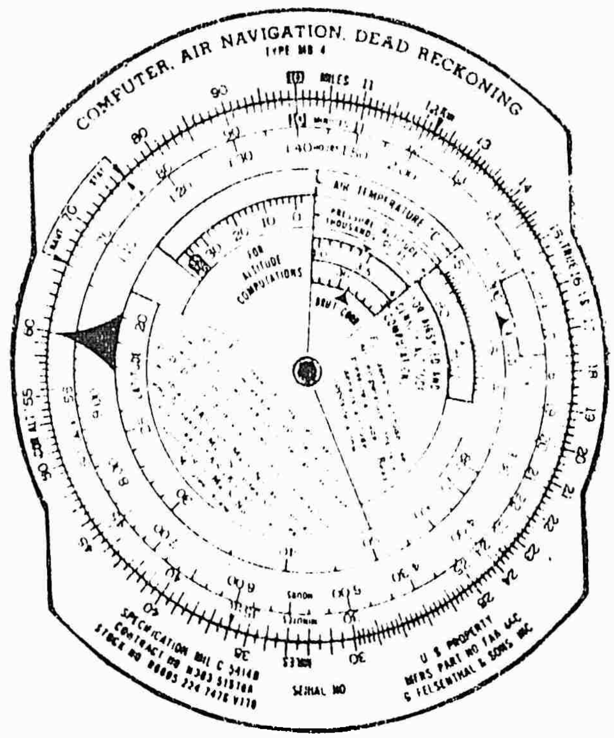


Figure 1-1. Slide Rule Side of CPU-26A/P

REVIEW MATERIAL

Introduction

The CPU-26A/P computer is a very handy, yet seldom used, piece of flying equipment. All pilots used it extensively during Undergraduate Pilot Training (UPT). Many still remember how to use it, but some do not use it as often or as effectively as they could. This chapter reviews some of the basic uses of this handy device. It begins with a description of the computer, then discusses using the computer to solve TACAN fix to fix problems for heading, distance, and ETE. Solving problems involving fuel computations, ground speed, distance, and ETE relationships, and finally, determining visual descent points are described. The chapter concludes with a summary and a selection of exercises to allow pilots to assess their knowledge of the use of the computer.

Description

Familiarity with the computer is necessary if the pilot is to use it effectively. Therefore, this chapter begins with a description of each side of the tool. The slide rule face of the computer consists of a basic circular slide rule adapted specifically to flight problems. Referring to Figure 1-1, it can be seen that this side consists of several scales, fixed and

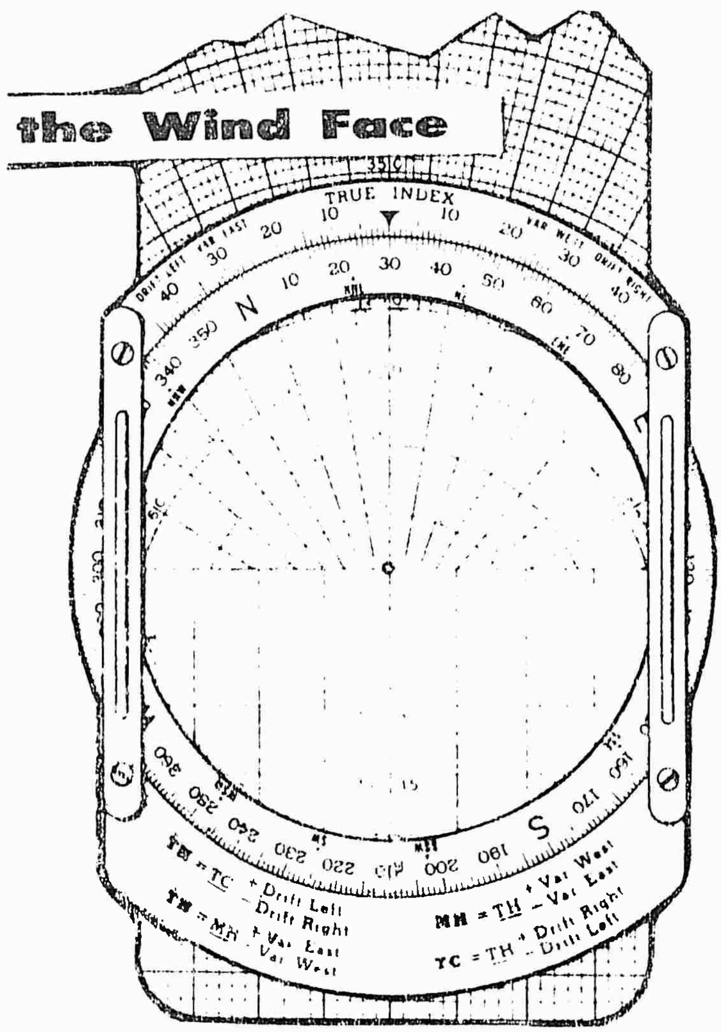


Figure 1-2. Wind Face of CPU-26A/P

moveable. which can be positioned to solve many types of problems. The two outside scales (one fixed and one moveable) both have reference marks called the *ten index*. The fixed or outside scale is marked in miles. The moveable inside scale is marked in minutes and hours and has a rate or *speed index* at the 60 minute point. This side of the computer is used to solve fuel, rate, and descent and climb gradient problems.

The other side of the computer, shown in Figure 1-2, is called the *wind face* and consists of a frame, a rotating transparent plate with a compass rose, and a slide. The slide has a low speed side marked from 0 to 275 and a high speed side marked from 60 to 840. The side used depends on the approximate speeds encountered in the problem to be solved. The frame consists of a reference mark labeled *true index* and drift correction scales to the right and left of the reference mark. The transparent disc can be rotated to any desired direction under the reference mark and has a compass rose around the outer edge. The center of the disc has a small black hole called the *grommet*. This side of the computer is used to solve the heading and distance portion of TACAN fix to fix problems.

TACAN Fix To Fix Problems

As previously noted, TACAN fix to fix problems begin on the wind face of the computer. As with all navigation aid problems, the first step is to tune and identify the desired navigational

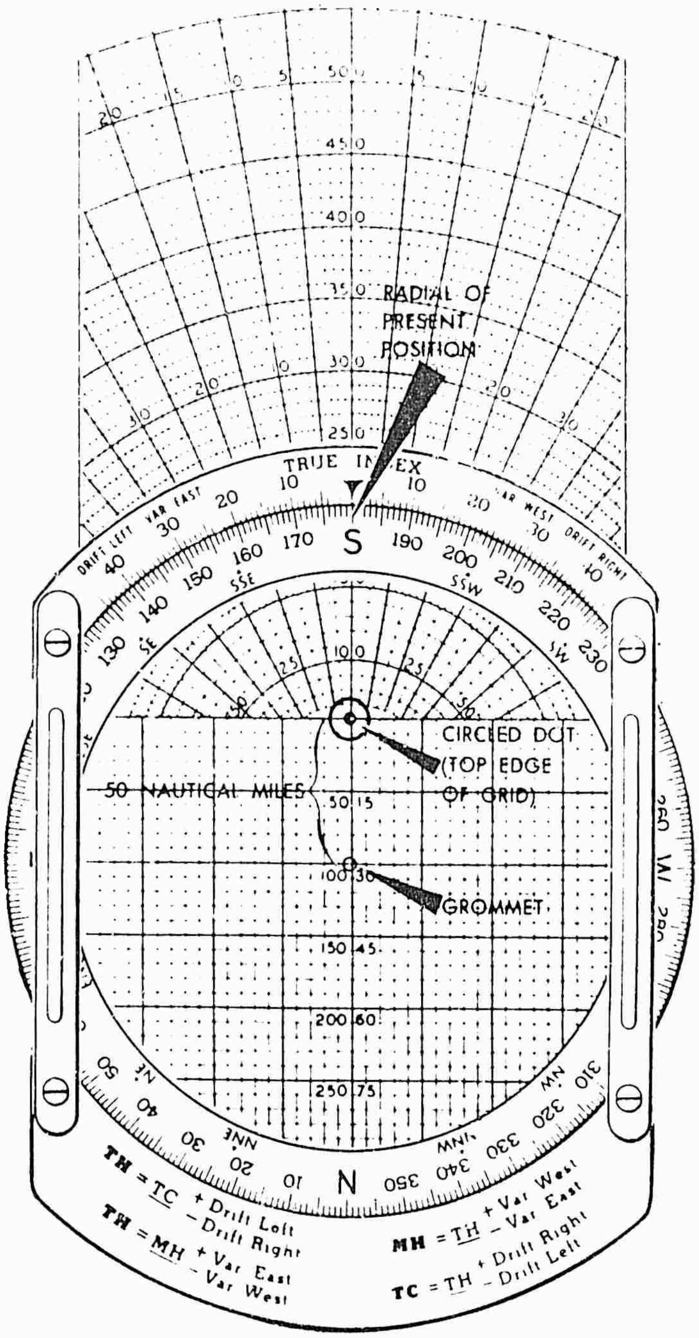


Figure 1-3. TACAN Fix To Fix Example

aid, and monitor the aural identification signal throughout the maneuver. Referring to Figure 1-3, the next step is to set up the computer as follows. Set the radial of the present position under the index. Then position the grommet over a convenient horizontal grid of the slide and establish a representative scale to use for mileage. For example, each vertical division could represent 5 miles. Then mark the present position along the centerline of the slide at the distance from the grommet corresponding to the present TACAN DME. This mark now represents the present aircraft position and should be circled to prevent confusion later. Next, do this same process for the desired TACAN fix, using the same scale for mileage. This is illustrated in Figure 1-4a. If the plate is now rotated, as shown in Figure 1-4b, so the desired fix is directly above the present position (circled), the no wind heading to the desired fix is under the index. Applying drift will yield the magnetic heading to the desired TACAN fix.

Note the relationship established. The grommet represents the TACAN station and the marks on the plate represent the desired fix and the aircraft present position. The ground distance from the aircraft present position to the desired fix can easily be determined from the scale. If for example, each division of the scale represents 5 miles and there are 10 divisions between the two marks representing the two fixes, the aircraft is 50 miles from the desired fix. This information can be used with the ground speed to determine the time required to

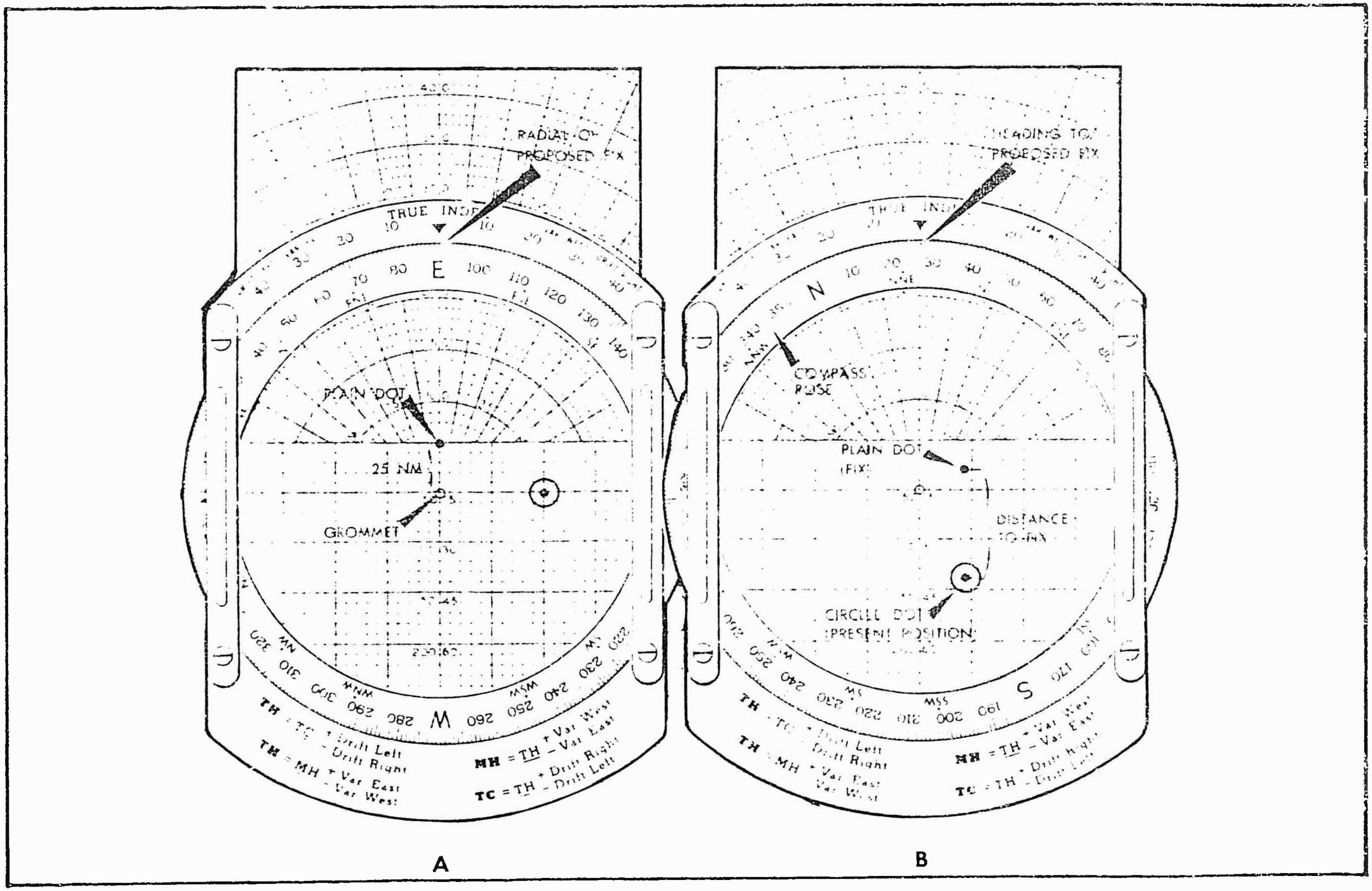


Figure 1-4. TACAN Fix To Fix Example

reach the desired fix, as shall be shown in the next section. In addition, if the procedure is repeated at regular intervals the aircraft's progress to the desired fix can be tracked and the heading and ETE can be updated as required.

Solving Ratio Type Problems

The slide rule face is used to solve ratio type problems involving fuel, distance, and ground speeds. Time and miles scales are constructed such that any relationship established between two quantities will be true for all the numbers around the scale. This property can be used to relate known quantities and to solve for unknowns. For example, problems involving time, rate, and distance are easily solved using the slide rule face.

Time, rate, and distance are related by the expression, the distance is equal to the rate multiplied by the time spent at that rate. Problems involving these quantities can be quickly solved by setting the rate index of the computer (the triangle under the 60 on the inner scale) opposite the rate (the airspeed or groundspeed) on the outer scale. Then, any time located on the inner scale will be adjacent to the distance covered in that time on the outer scale.

For example, assume an aircraft is maintaining a groundspeed of 250 knots and is 375 nautical miles from the next turn point. How long will it take to reach the turn point? If

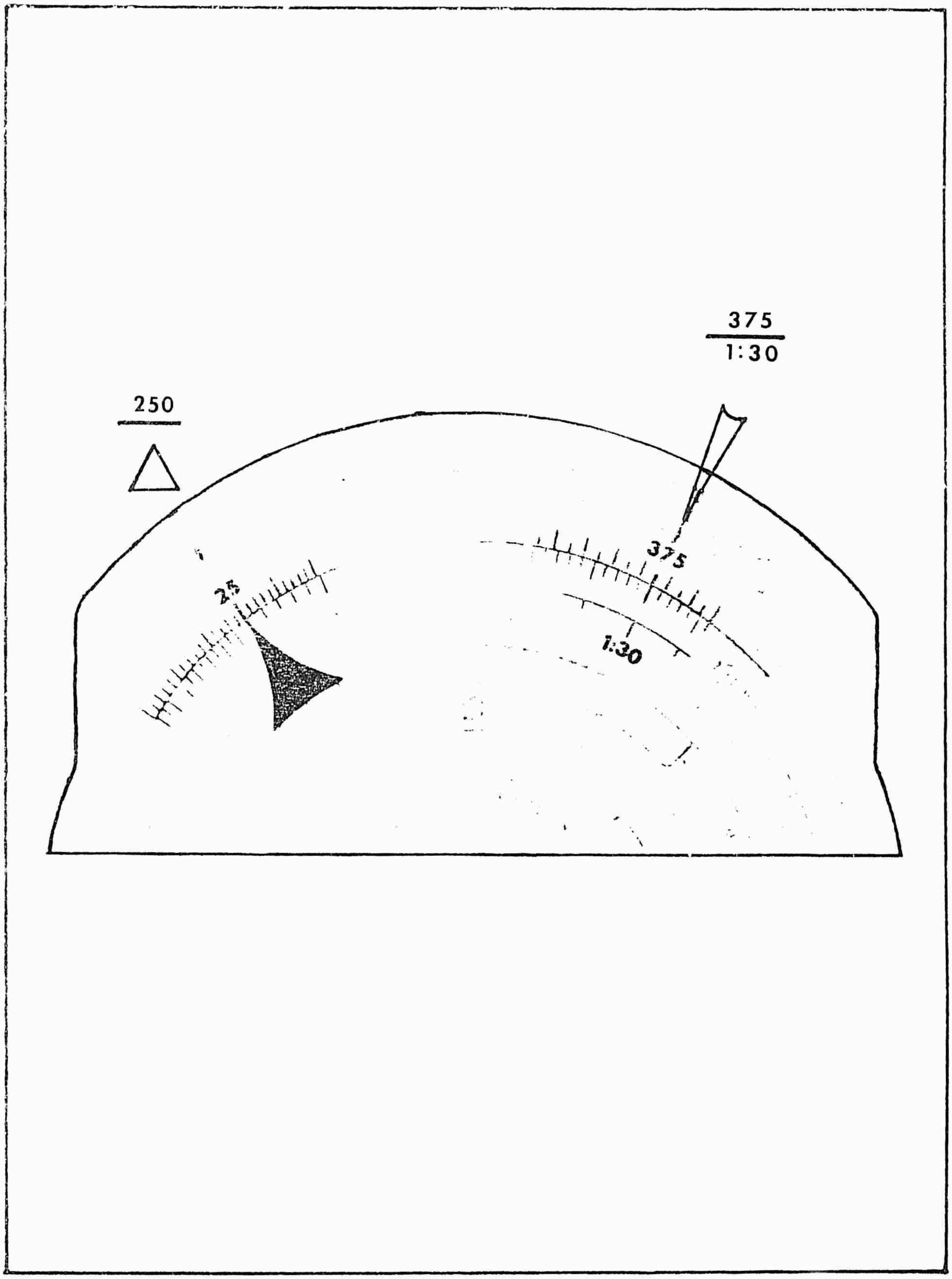


Figure 1-5. Time/Distance Problem Example

the rate index is set opposite the 250 on the outer scale as shown in Figure 1-5, the time required to travel 375 nautical miles will be found on the inner scale opposite the 375 on the outer scale. In this problem, the answer of 90 minutes can be read on the inner scale opposite the 375 on the outer scale. Similarly, the time to travel any distance at this speed can be determined from the inner scale opposite the distance on the outer scale. If the distance to be traveled in a given time is desired, it can be found on the outer scale opposite the time on the inner scale.

The same procedure can be used to determine ground speed if the distance traveled in a specified time is known. Simply set the known distance on the outer scale opposite the time required to travel this distance on the inner scale and read the ground speed opposite the rate index.

If it is desired to work in minutes and seconds instead of hours and minutes, use the smaller rate index which takes the place of the 36 on the inner scale (see Figure 1-6) instead of the larger rate index and apply the same procedures.

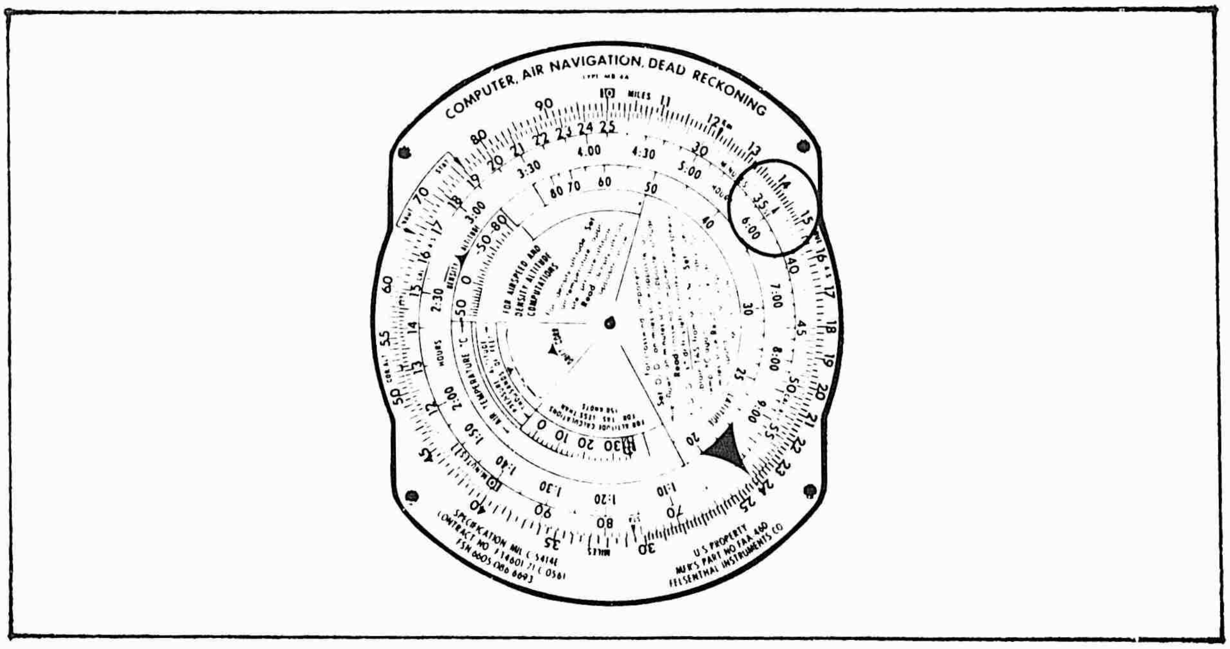


Figure 1-6. Seconds Index of CPU-26 A/P

This is very useful in determining the time to cover relatively small distances such as the time required to travel from the Final Approach Fix (FAF) to the Visual Descent Point (VDP) and/or Missed Approach Point (MAP) for a nonprecision approach.

Problems involving fuel consumption can be solved in a manner similar to that discussed above. The rate index is now set opposite the fuel flow instead of the groundspeed. The outer scale now represents fuel instead of distance and a fuel verses time relationship is established. For example, if 12,500 pounds of fuel has been consumed in 42 minutes, how long will the remaining 34,500 pounds of fuel last and how much fuel will be used in the next 20 minutes of flight? To determine this

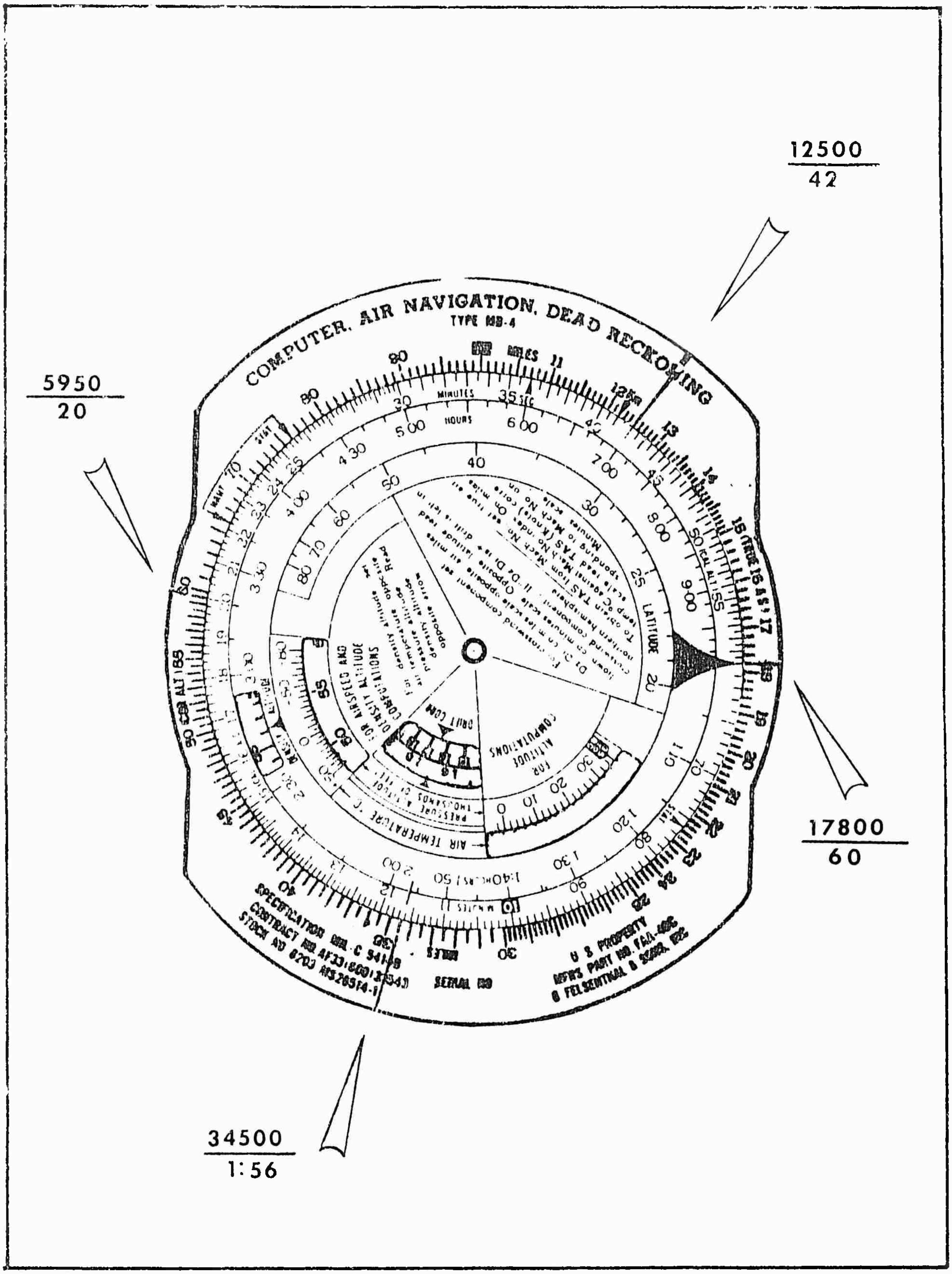


Figure 1-7. Time/Fuel Problem Example

information refer to Figure 1-7. Set up the computer to place the 12,500 pounds of fuel used on the outer scale adjacent to the 42 minutes required to use it on the inner scale and read the fuel flow of 17,800 pounds per hour opposite the rate index. With this relationship established, note that the remaining 34,500 pounds of fuel (on the outer scale) will last one hour and fifty six minutes (found on the inner scale). Similarly, to determine the fuel to be used in the next 20 minutes, locate twenty minutes on the inner scale and note the fuel consumed (5950 pounds) on the outer scale opposite the twenty minutes.

Climb And Descent Gradient Problems

Climb and descent gradients can also be determined using the computer. Since this type of problem involves working with simple proportions, the computer is used as a circular slide rule. For example, if a desired altitude change is set on the outer scale opposite the number of miles to accomplish the change on the inner scale, the altitude change per distance will be found on the outer scale opposite the ten index. If the altitude change is expressed in feet and the distance is expressed in nautical miles, the answer (gradient) will be in feet per nautical mile.

For example, suppose an aircraft is at 2100 feet MSL at the FAF on the TACAN approach shown in Figure 1-8. The figure shows that the VDP is 4.2 nautical miles from the FAF and the minimum descent altitude is 1020 feet MSL. What is the minimum descent gradient required to assure the aircraft reaches 1020 feet MSL prior to the VDP?

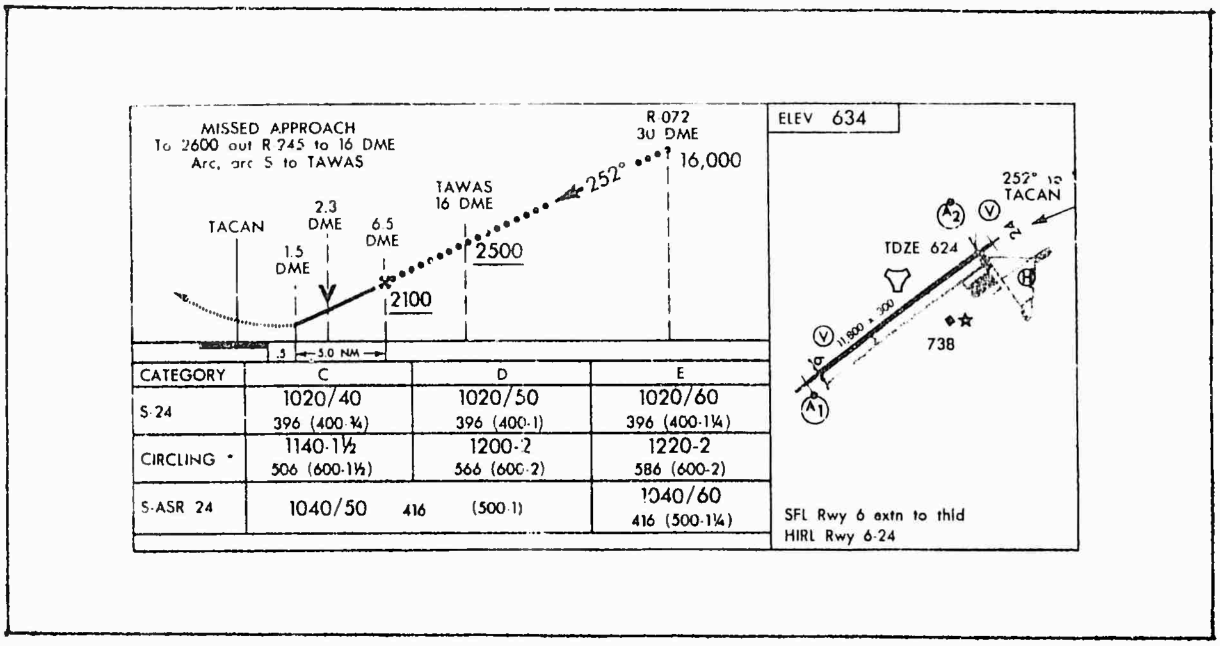


Figure 1-8. Descent Gradient Example

To solve this problem, place the altitude change, 1080 feet (2100 - 1020) on the outer scale adjacent to the distance to make the change, 4.2 NM (6.5 - 2.3) on the inner scale. The required minimum gradient (258 feet per NM) will then be found on the outer scale opposite the ten index. Thus the aircraft must descend at least 258 feet per nautical mile to be at the minimum descent altitude of 1020 feet MSL at the VDP. Descent gradients to reach a final appproach fix altitude prior to the

FAF, and minimum climb gradients required during an instrument departure, are calculated in the same manner.

Establishing Visual Descent Points

Many nonprecision approaches do not have a published Visual Descent Point (VDP). Thus the pilot must do without or use another method to determine where to begin the descent from the minimum descent altitude (MDA). Some pilots simply wait until the runway "looks right", but narrow runways, night operations, sloping terrain, and a lack of terrain contrast can make this practice difficult and often dangerous. The CPU-26A/P computer can be used to assist the pilot in determining the location of a VDP.

Since the VDP is simply a point from which a descent may be initiated from the MDA to allow the aircraft to follow a normal rate of descent to the runway threshold, the pilot must decide upon a suitable rate of descent. As most pilots are used to a 3 degree glide slope, a 300 feet per nautical mile rate of descent provides a familiar environment and the visual cues and power settings during the descent will approximate those encountered on a typical precision approach. It should be stated that although 300 feet per nautical mile was chosen for this example, any rate of descent could be used. Once this desired rate of descent is chosen, the computer can be used to determine where the descent from the MDA should begin.

Referring to Figure 1-9, the pilot will note that the problem is to locate where to begin a predetermined rate descent to lose the altitude from the MDA to the runway threshold. One way to do this is to set the ten index of the inner scale adjacent to the rate of descent in feet per nautical mile on the outer scale. If the altitude to be lost (MDA minus runway elevation) is found on the outer scale, the distance from the runway threshold to begin the descent will be found adjacent to the altitude on the inner scale. If DME is to be used to locate the VDP, the pilot must add or subtract the distance of the TACAN from the runway threshold to determine the DME of the VDP. If the pilot wishes to locate the VDP based on a time from the FAF, simply determine the distance from the FAF to the VDP and calculate a time based on the ground speed as discussed previously.

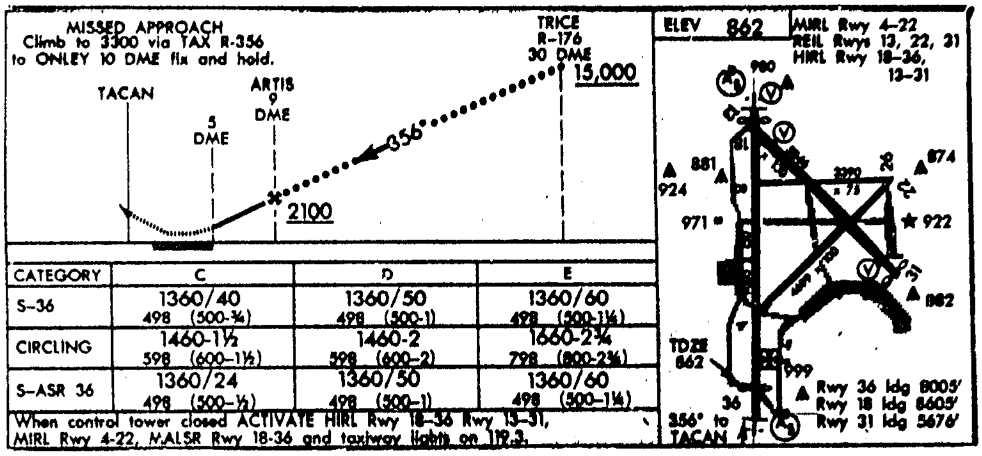


Figure 1-9. Visual Descent Point Example

To illustrate this procedure, refer to Figure 1-9, and assume the pilot wishes to descend at a rate of 300 feet per nautical mile. Where should the VDP be located?

The first step is to determine the amount of altitude to be lost. In this case, subtracting the runway elevation (862 feet MSL) from the MDA (1360 feet MSL) results in 498 feet to lose. Setting the ten index of the inner scale of the computer, adjacent to 300 feet per nautical mile on the outer scale of the computer, the pilot will note that 1.67 or approximately 1.7 nautical miles will be required (on the inner scale) to lose 498 feet (on the outer scale) at this rate of descent. Noting that the runway threshold is at 5 DME, the pilot adds 1.7 nautical miles to the 5 DME and finds the VDP would be at 6.7 DME.

Should the pilot desire a backup procedure, the time from the FAF to the VDP could be calculated. Noting that the FAF is at 9 DME, the distance from the FAF to the VDP is 2.5 nautical miles (9 - 6.7 = 2.3). At a ground speed of 180 knots for example, a time of 50 seconds would be obtained by use of the procedures previously discussed. Thus if the pilot started a stop watch at the FAF, 46 seconds later the aircraft should be very close to the VDP.

Summary

This chapter has reviewed some of the basic uses of the CPU-26A/P Computer. It began with a brief description of the computer. Procedures to solve for the required heading and ground distances during a TACAN fix to fix problem were then discussed. Procedures to solve ratio type problems for fuel, time, and distance were then illustrated and the section concluded with a review of procedures used to solve for climb and descent gradients and Visual Descent Points. The problems illustrated could be solved by other means, however, the computer offers a simple and direct method to do so.

REVIEW PROBLEMS

1-1. An aircraft is currently on the 176 degree radial at 74 DME of the TRASH TACAN. The pilot wishes to proceed direct to the TRASH 085 degree radial at 65 DME.

a. What should be the initial no wind heading?

b. What is the ground distance from the present position to the desired fix?

c. With a ground speed of 300 knots, what is the ETE to the desired fix?

1-2. An aircraft has 85,000 pounds of fuel. With a fuel flow of 20,000 pounds per hour, how much fuel will the aircraft have remaining 90 minutes from now?

1-3. An aircraft is in a holding pattern waiting for snow removal equipment to clear the runway. The pilot has 90,000 pounds of fuel remaining and a fuel flow of 18,000 pounds per hour. How long can the aircraft hold and still depart with the 35,000 pounds of fuel required to reach an alternate?

1-4. Referring to Figure 1-10, and assuming the aircraft crosses the FAF at 1500 feet MSL, what is the minimum descent gradient it must maintain to be at 480 feet MSL at the VDP?

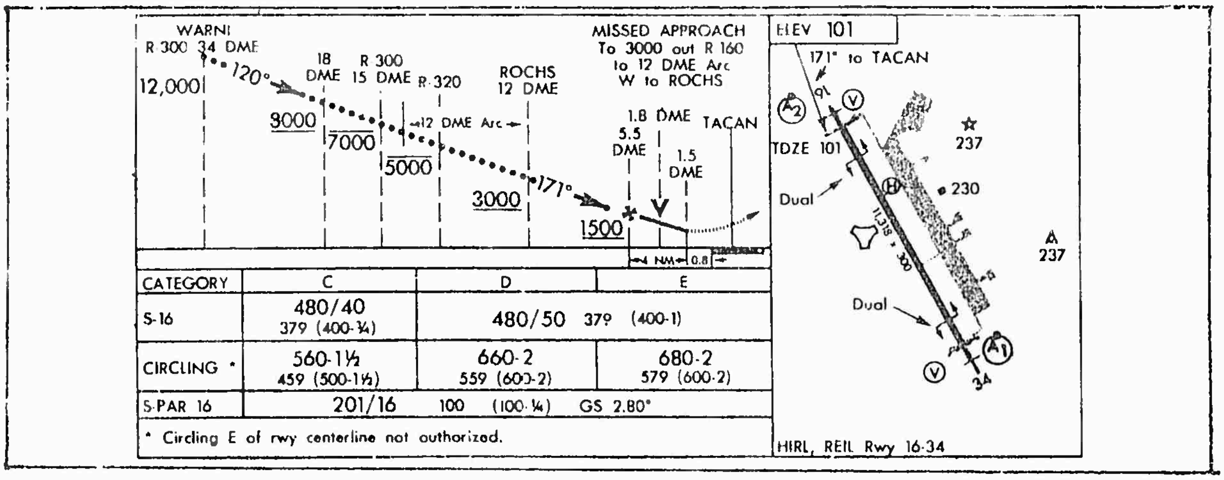


Figure 1-10. Descent Gradient Problem

1-5. Referring to Figure 1-11 below, determine a suitable VDP based on a TACAN DME. Assuming a ground speed of 180 knots, determine the approximate time from the FAF to the VDP and to the MAP.

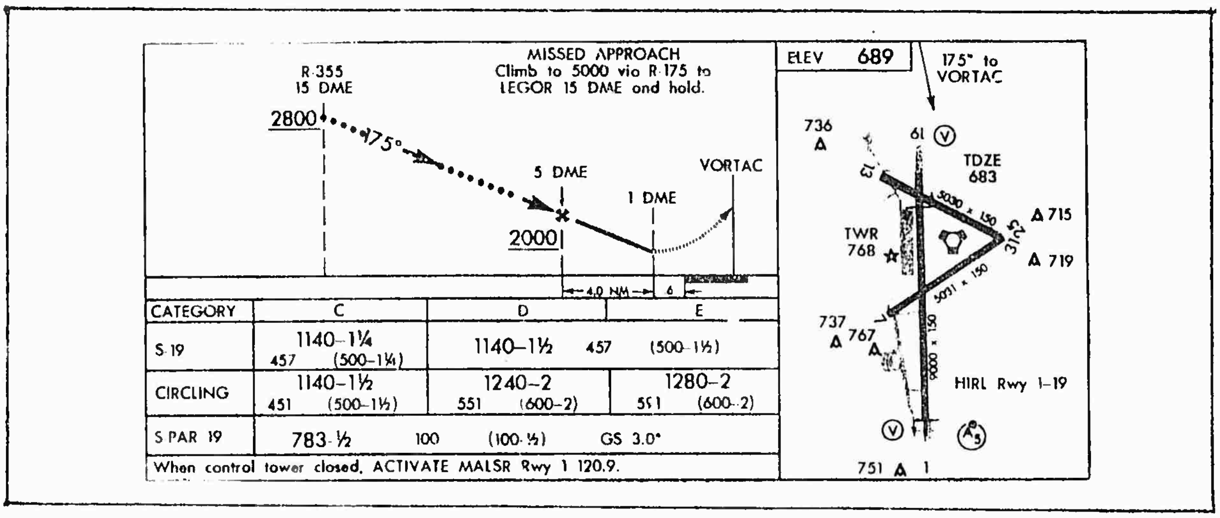


Figure 1-11. Visual Descent Point Problem

Chapter Two

BASIC NAVIGATION

OBJECTIVES

At the completion of this lesson the pilot will be able to:

1. Use the PLU-1/C Navigation Plotter to plot courses, determine ground distances, and plot TACAN range and bearing information on an aeronautical chart.
2. Describe significant features of, and the information to be found on a typical aeronautical chart.
3. Plot a complete flight plan, including TACAN range and bearing information, course, and ground distances, on an applicable aeronautical chart.

REVIEW MATERIAL

Introduction

This chapter is a review of some of the basic navigational procedures learned in former flight training programs. It begins with a discussion of the PLU-1/C Navigation Plotter and how it can be used to determine mileage, courses, and TACAN information from an aeronautical chart. Subsequent sections discuss typical aeronautical charts and the information these charts contain. Plotting an example flight plan on an aeronautical chart is then discussed, emphasizing course, TACAN information, and ground distance computations.

Description

The aeronautical plotter shown in Figure 2-1, is a navigational instrument designed specifically to assist pilots to draw and measure courses, plot positions, and plot navigational aid information on an aeronautical chart. It consists of a rectangular shaped bottom half designed to be used as a straight edge and to measure ground distances on a chart. The top half of the plotter is used to measure the direction of courses laid out on a chart.

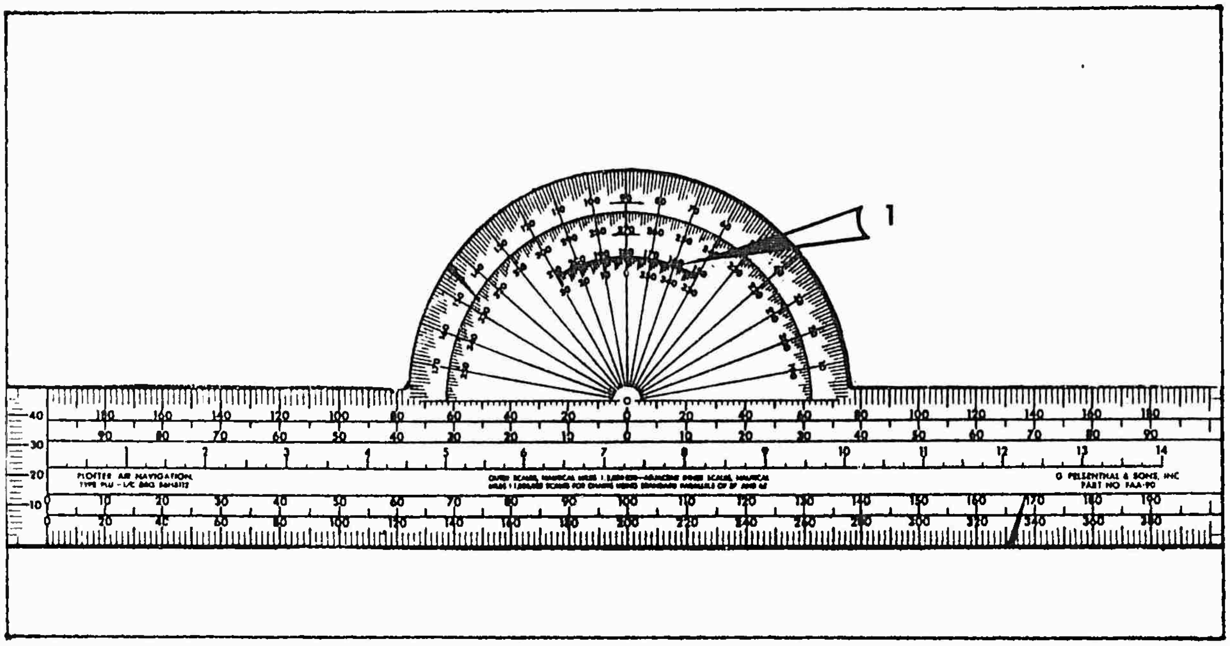


Figure 2-1. The Aeronautical Plotter

The top part is calibrated in degrees with two complete scales, one of which is numbered from 0 to 180 degrees and one which is numbered from 180 to 360 degrees. The outside scale is numbered so as to increase from 0 to 180 degrees in a counterclockwise direction and is used to measure courses from north through east to south. The second outermost scale has numbers increasing from 180 to 360 degrees also increasing in the counterclockwise direction and is used to measure courses from south through west to north. Two inner partial scales (see 1, Figure 2-1) are used to measure courses near 180 and 360 degrees. At the center of the semicircular top portion is a small hole called the *grommet*, used as a center point for all course measurements.

Determining a Course and Distance

Using the plotter to determine the course and distance between two points on a chart is very easy. The first step is to locate and mark the end points of the desired course. Next mark the desired course on the chart using a straight edge. Now, lay the straight edge of the plotter along the course line and center the grommet on a meridian near the center of the course (see Figure 2-2). The true course may now be read as the intersection of the meridian upon which the grommet is centered and the scale on the plotter. Which scale to be used can be determined by noting the small arrows on the scale. Simply use the scale associated with the arrow pointing in the direction the aircraft is to travel as shown in Figure 2-2. It is also a good idea to note a rough heading from the chart and compare this with the course determined from the plotter. This will prevent using the wrong scale on the plotter and attempting to fly a reciprocal heading. The course thus determined is a true course since it is measured against a meridian which runs from pole to pole. Since the heading systems of most aircraft indicate magnetic bearing, the true course must be converted to a magnetic course. To do this, find the line of magnetic variation nearest the center of the course plotted. This line is generally blue and will be labeled with a number and a direction. If the direction is east, simply subtract the number of degrees on the magnetic variation line from the true course previously determined. If the variation is west, add the variation to the true course. This procedure will result in a course to be flown with reference to a magnetic heading system. Once the course is known, the pilot must determine the ground distance between two points.

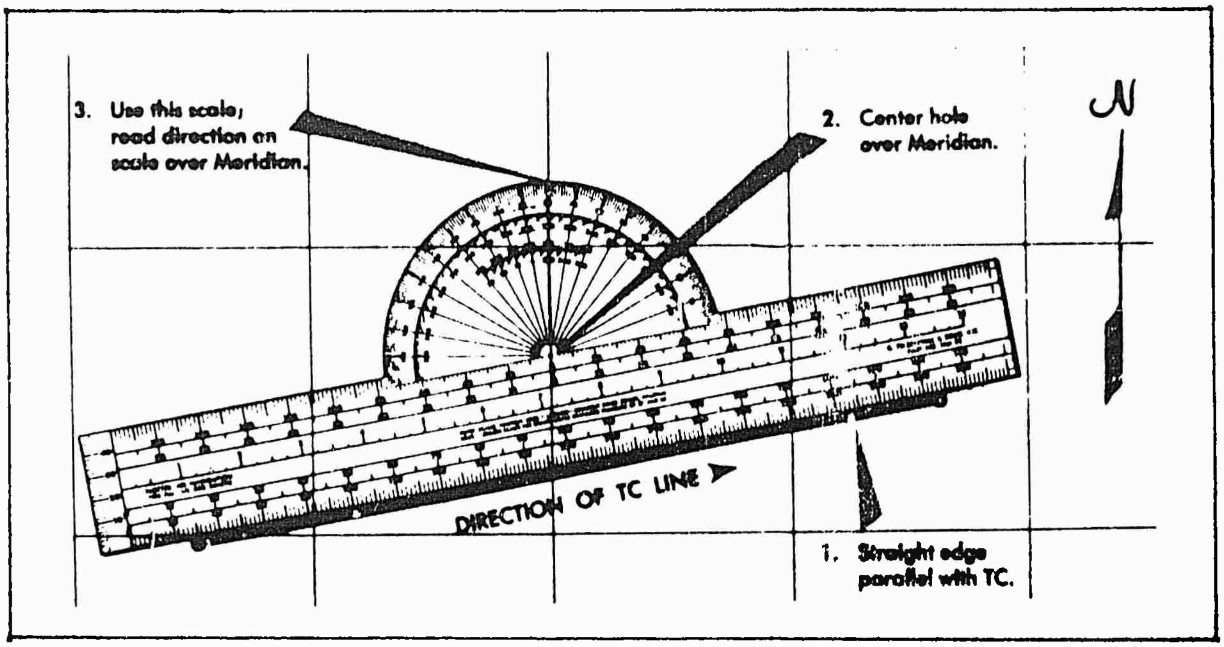


Figure 2-2. Measuring a Course.

The bottom portion of the plotter has five mileage scales as shown in Figure 2-2. Although these scales are not as precise as some other methods of measuring distance, they are quick and sufficiently accurate for navigational use. To use these, note the scale of the chart being used and measure the distance between the end points of the course line using the appropriate scale. The resultant distance is in nautical miles.

Aeronautical Charts

The aeronautical chart is one of the pilots most basic, yet vital tools. It is simply a pictorial representation of the surface of the earth. However, modern charts contain many additional symbols and notes representing navigational aids and other data necessary for safe flight. This section discusses the scales, symbology, and aeronautical information available on the charts commonly used by SAC pilots.

The scale of a chart (see Figure 2-3) is simply the ratio between any given unit of length on a chart and the distance that length represents on the surface of the earth. For example, a Tactical Pilotage Chart (TPC) used during a low level navigation training mission will have a scale of 1:500,000 meaning 1 unit on the chart represents 500,000 units on the earth's surface. This means that 1 inch on the chart represents 500,000 inches on the earth's surface or approximately 7 nautical miles. Pilots can also measure a latitude line, since 1 degree of latitude is always equal to 60 nautical miles, regardless of the scale.

TPC H-24A

UNITED STATES

SCALE 1:500,000

Prepared and published by the Defense Mapping Agency Aerospace Center, St. Louis Air Force Station, Missouri 63118. Base information Compiled January 1967. (NOS). Revised December 1981. (NOS). (Revision limited to aeronautical information).

Lithographed By DMAAC 3-83

EDITION 10

Figure 2-3. Sample Chart Scale

As mentioned previously, a chart legend also explains many of the symbols used on that chart. Figure 2-4 is a sample chart legend from an Operational Navigation Chart (ONC). Note that the basic contour lines are at 1000 foot intervals (see 1, Figure 2-4). This means that points of equal elevation have been joined to form lines of constant elevation and that these lines have been repeated for every 1000 feet of change of elevation. If the contour lines are close together, the terrain elevation is changing more rapidly than if the lines are far apart. Sometimes intermediate contour lines are illustrated at 500 and 1500 feet intervals. These will be different type lines (possibly dashed) to prevent confusion.

Another very important terrain feature shown on an

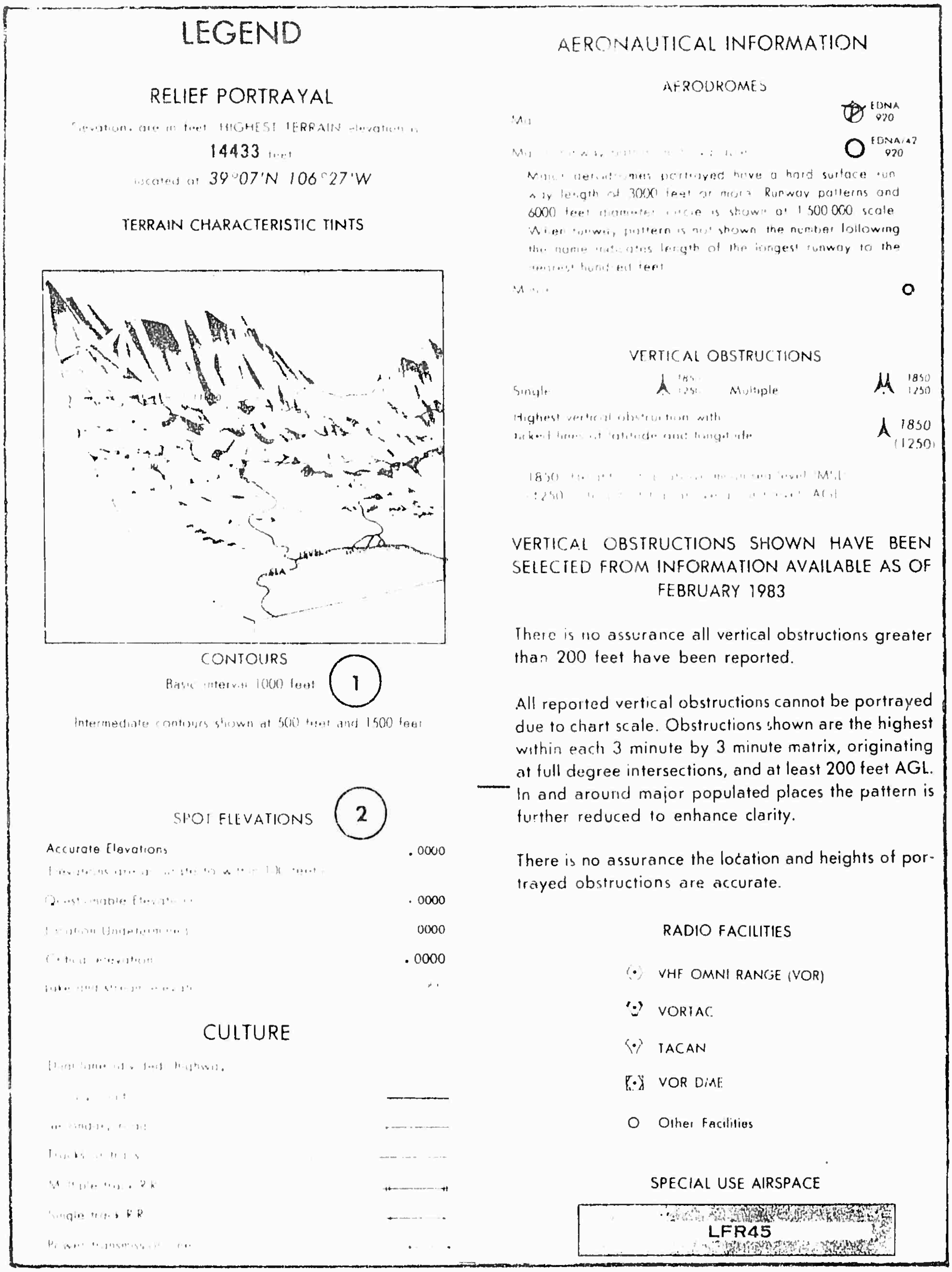


Figure 2-4. Sample Chart Legend

aeronautical chart is the spot elevation as shown in 2, Figure 2-4. This is the height of a particular point of terrain above some established datum plane, usually sea level. Spot elevations are shown on both TPCs and ONCs and if preceeded by a black dot, indicate the peak elevation plus or minus 100 feet. A small x before the elevation would indicate an approximate elevation. If neither an x or a period preceeds the elevation, the accuracy is doubtful, so watch out! Note also, critical peaks (those higher than all others in the area), are shown as a period and heavy black numbers. This information could be very useful during an emergency or unscheduled climb as it can be used to determine safe terrain clearance for that immediate area.

Cultural information used on a chart will also be explained in the legend. Towns, roads, railroads, lakes, rivers , mines, and dams are a few of the cultural features often depicted. Once again, referring to Figure 2-4 illustrates how these features may be shown. For example, towns are usually shown as a rough outline of the shape of the town or simply as a small circle if the town is very small. Roads may be shown as single black lines and railroads are often depicted as cross-hatched lines. Major power lines are usually shown as dotted lines. Since these symbols may vary slightly, a pilot should review the chart legend during mission planning to become familiar with the symbols on the chart to be used.

An aeronautical chart also depicts selected aeronautical information such as aerodromes, obstructions, navigation aids, and special use airspace. The sample legend in Figure 2-4 may be used to discuss this information.

As depicted on the sample legend in Figure 2-4, major aerodromes with a minimum of 3000 feet of hard surface runway are shown with a runway pattern and a 6000 foot diameter circle. This circle is centered on the actual position of the aerodrome. A star depicted near the circle represents the position of a rotating beacon. Note that not all aerodromes have a runway depicted. In such cases the length of the longest runway to the nearest hundred feet follows the name of the field.

Vertical obstructions are also depicted on the chart and discussed in the chart legend. For example, Figure 2-4 depicts single towers as a single spike mark with two elevations. These elevations are the height of the top of the obstruction above mean sea level (top number) and above the ground (number in parenthesis). Note that multiple towers are represented in a similar manner except that two spikes are shown. Note also the series of disclaimers! Obviously a chart can only be accurate up to the printing date, so the cartographers have devised a method to plot new or recently discovered obstructions. They do this by publishing a CHart Update Manual (CHUM) which adds all known obstruction information up to the date of the CHUM. Be sure to update any chart prior to use. Discovering an unplotted tower at low level could ruin a whole day!

As can be seen from the sample legend, aeronautical charts use the same symbols to depict navigational aids such as TACANs and VORs as do instrument approach plates (IAP). The chart will depict the symbol in the correct location along with the name of the facility. In addition, some Operational Navigation and Tactical Pilotage Charts list the frequency of selected TACAN stations. For the other stations and for charts that do not list this data, the pilot must refer to the appropriate enroute supplement.

The last information to be discussed concerning the chart legend is the depiction of special use airspace. Most Alert, Danger, Military Operations Area, Prohibited, Restricted, or Warning areas are shown as blue-shaded areas. The first letter of the designation will indicate the type of area depicted. For example, an area labeled A-203 would be an Alert area, such as a local flying area, and not necessarily restricted to other traffic. Most areas are shown, but not all areas are used continuously. Pilots should check the Notice to Airmen (NOTAMS), a local flight service station, or the appropriate controlling agency prior to mission planning to fly through a depicted area. Additional information on each area such as altitudes, boundaries, and hours of operation, may be found in the Flight Information Publications (FLIP).

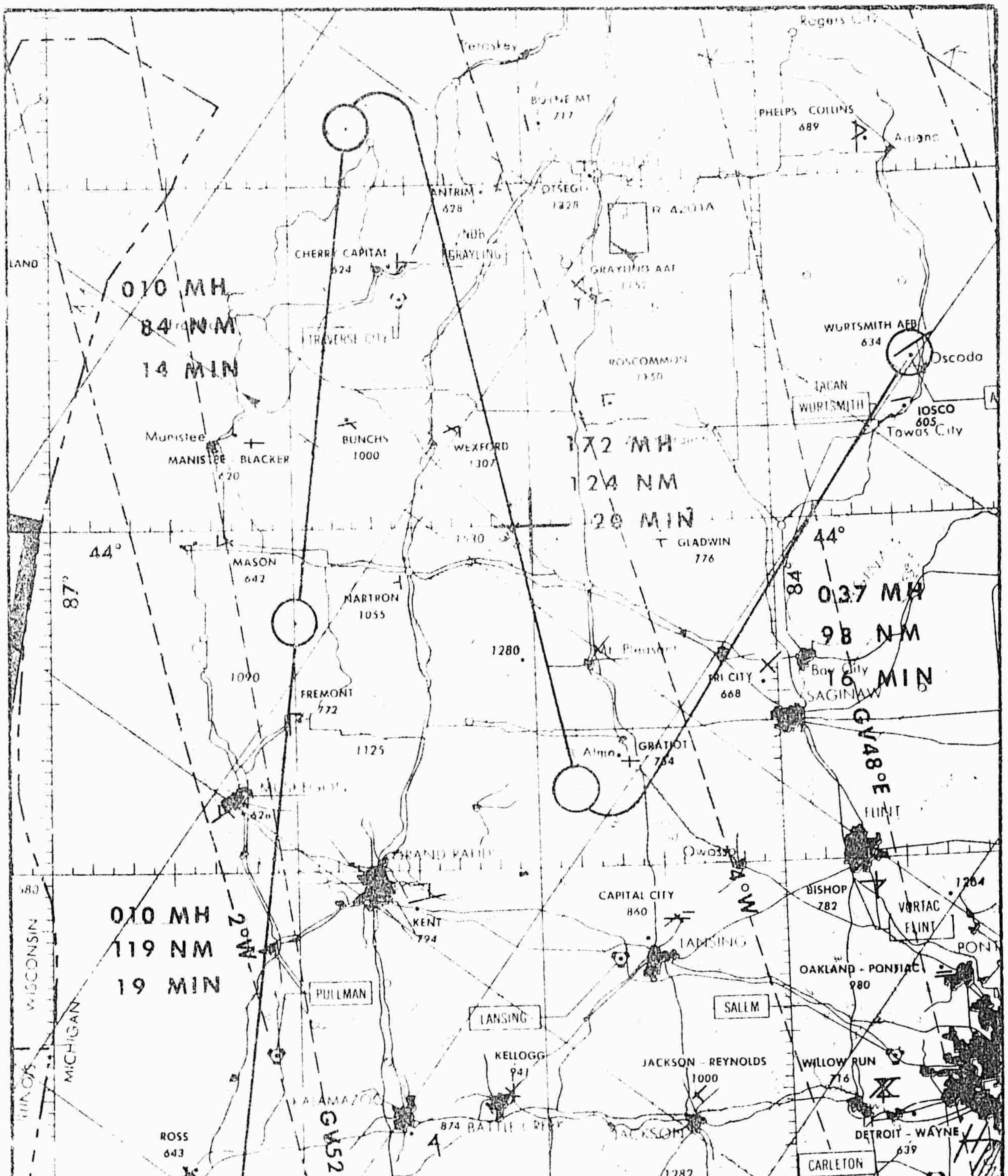


Figure 2-5. Sample Pilot Chart

Plotting Flight Plans

Although most SAC pilots have a navigator on board to plan the mission and navigate the aircraft, the position of the aircraft and the accuracy of the flight plan remain the responsibility of the pilot. Many missions begin with a well defined plan and an accurate chart of the proposed route; however, due to unforeseen circumstances, such as mission changes or hazardous weather, missions often must be replanned inflight. Replotting a flight plan inflight can often reduce the confusion and assist the pilot to monitor the progress of the new mission and intelligently communicate the new route of flight to ARTCC.

Plotting a flight plan is really just using the skills reviewed earlier in this chapter. It consists of transferring TACAN range and bearing information onto an aeronautical chart, cross checking headings, and calculating estimated times of arrival to back up the navigator.

Suppose, for example, an aircraft is near Fort Wayne, Indiana, heading west for a low level training route when notified that the route is closed. The crew elects to fly an abbreviated navigation leg back to their home station (Wurtsmith AFB, MI) to complete the mission with transition work in the local area. The navigator requests the pilot fly the aircraft from its present position direct to the South Bend VORTAC, then to the Traverse City 202 degree radial at 60 DME, then to the

Traverse City 350 degree radial at 30 DME, then to the Lansing 353 degree radial at 30 DME, direct to Wurtsmith. Since the navigator is busy replanning the navigation leg, the pilot is asked to cross-check headings, distances, and determine a new ETA to Wurtsmith. The navigator will request airspeeds to maintain an average ground speed of 370 knots.

Referring to Figure 2-5, the pilot could proceed as follows. Since the first point is the South Bend VORTAC, the pilot should simply circle this point on the chart and move on to the second point. Since the next point is given as a TACAN magnetic radial and DME and the information on an aeronautical chart is oriented to true north, magnetic variations must be applied. Since the pilot must add a west variation (and subtract an east variation) from the true course to determine the magnetic course, the pilot must simply reverse the process to determine a true position from a magnetic one. Thus, the Traverse City 202 degree radial combined with 4 degrees of west variation results in a true position along the 198 degree radial on a chart. All the pilot must do is lay out the 198 degree radial on the chart and use the appropriate scale on the plotter to locate the 60 DME fix along that line. Plotting this point and connecting it with the South Bend VORTAC results in the intended course. The heading can be determined with a plotter (applying magnetic variation) and the distance can be measured with dividers or with the appropriate scale of the plotter. In the example used, a true heading of 006 degrees with a magnetic variation of 4 degrees west results in a no wind heading of 010 degrees. The distance between the two points is approximately 119 nautical miles. Knowing this distance, the pilot can use a CPU-26A/P computer to calculate an ETE of 19 minutes based on the navigator's planned 370 knots ground speed.

The rest of the flight plan can be plotted in a similar manner and the results would look like Figure 2-5. The pilot can thus back up the navigator's headings, monitor the position and progress of the aircraft, and determine an approximate ETA based on the sum of the times of the individual legs.

Summary

This chapter has reviewed some of a pilot's most basic navigational skills. The use of the PLU 1/C navigation plotter was first described, highlighting course, distance, and TACAN fix plotting. The aeronautical chart and the information it contains was then discussed. The chapter concluded with a practical application of the first two sections as plotting a flight plan was illustrated. Although this information is very basic, an occasional review is important. After all, safe flight often depends on precise navigation and the proper use of an aeronautical chart.

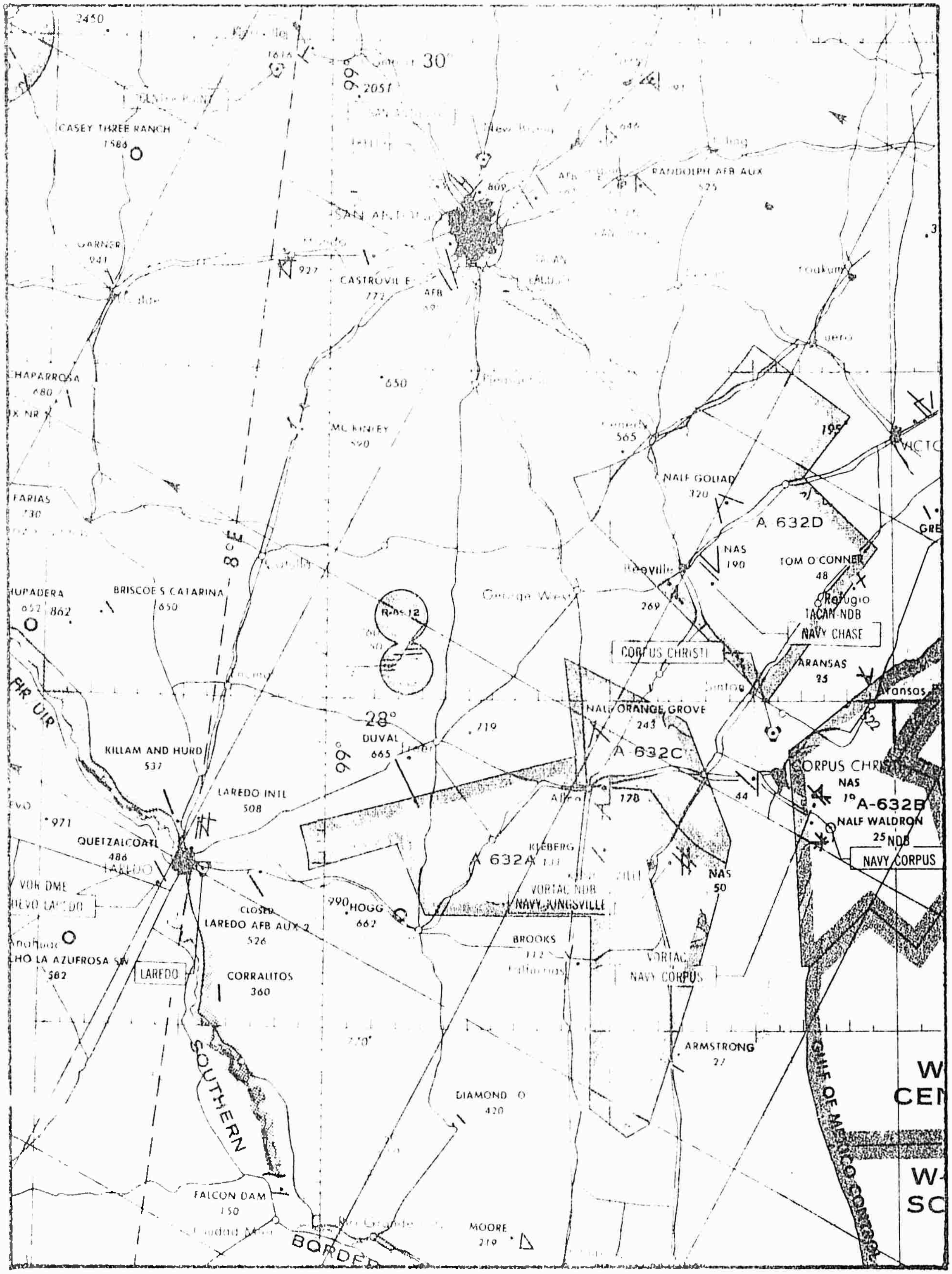


Figure 2-6. Sample Pilot Chart

REVIEW EXERCISES

2-1. Using the chart provided in Figure 2-6, determine the magnetic heading from the Corpus Christi 296 radial at 25 DME to the Center Point VORTAC.

2-2. Where would a pilot find information concerning the Alert areas depicted on Figure 2-6 between Corpus Christi and Laredo, Texas?

2-3. Using the chart provided in Figure 2-6, plot the following flight plan:

a. Depart Randolph AFB, Texas, using radar vectors direct to the San Antonio VORTAC, then direct to the Laredo 290 degree radial at 30 DME, then direct to the Corpus Christi 260 degree radial at 20 DME.

b. Determine the magnetic headings for each leg of the above flight plan.

c. Determine the ground distances for each leg of the above flight plan.

d. At an average ground speed of 350 knots, determine the ETE from Randolph AFB to the Corpus Christi radials.

Chapter Three

SIXTY TO ONE RULE

OBJECTIVES

At the completion of this lesson the pilot will:

1. Understand the theory and limitations of the sixty to one rule.

2. Be able to apply the sixty to one rule to determine initial pitch changes for climbs and descents.

3. Understand techniques to monitor the progress of climbs and descents to insure desired performance is being achieved.

4. Be able to apply the sixty to one rule to determine a heading to establish a desired offset for teardrop holding pattern entry and approach planning.

REVIEW MATERIAL

Introduction

This chapter discusses the sixty to one rule of instrument flying. It begins with a discussion of the theory and derivation of the sixty to one rule. Subsequent sections discuss applying the sixty to one rule to climb and descent problems and using the rule to determine offset headings for teardrop holding pattern entry and approach planning. The chapter concludes with a summary and a selection of review exercises.

Theory

The sixty to one rule is a very useful concept for instrument flying. Simply stated the rule says that for any aircraft, at any airspeed, a 1 degree pitch change will result in a climb or descent of 100 feet per nautical mile. Similarly, the rule can be applied in the horizontal plane and states that a 1 degree heading change will result in a 1 mile offset over a 60 mile course, or 100 feet of offset per nautical mile. Pretty simple, but a tool that can simplify descent and climb problems, assist in approach planning, and help utilize the basic concept of instrument flying.

For example, the "Control and Performance" concept of

Instrument flying requires that the pilot (1) establish an attitude or power setting on a control instrument, (2) trim to relieve control pressures, (3) cross check the performance instruments to assure the desired performance is being attained and finally, (4) adjust the attitude or power setting as necessary. The sixty to one rule can assist with steps (1) and (4) by providing an estimate for pitch changes, thus allowing the pilot to change the aircraft attitude a predetermined amount.

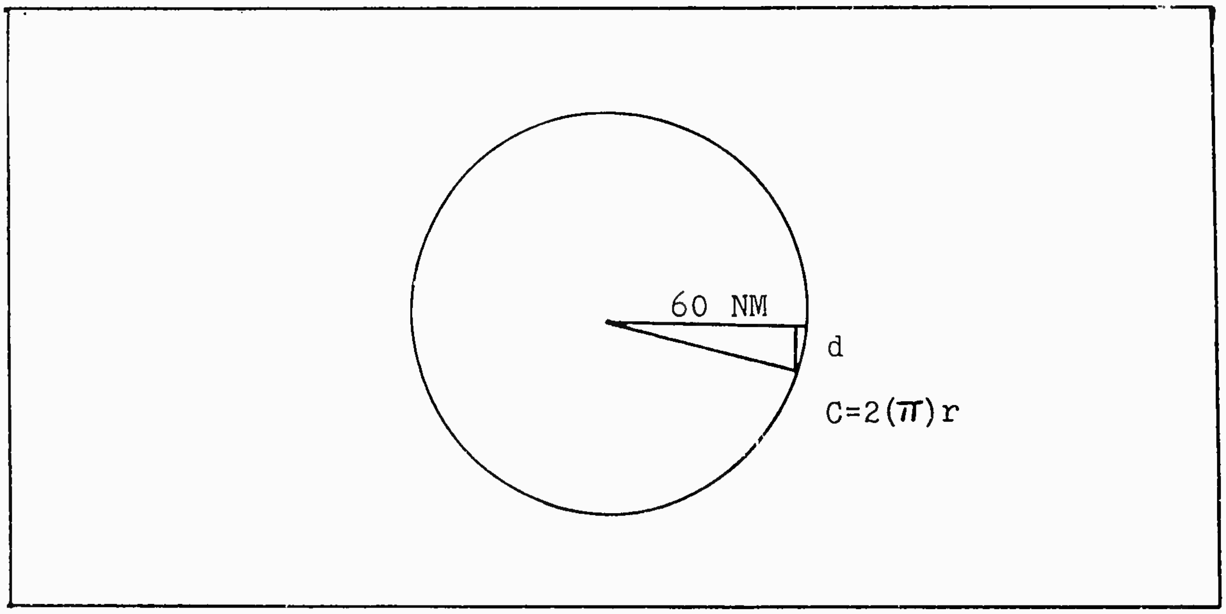


Figure 3-1. Theory of the Sixty to One Rule

Figure 3-1 illustrates the basic idea of the sixty to one rule. The aircraft is assumed to be at the center of a 60 mile radius circle and the pilot makes a 1 degree pitch change.

To make the computations easier, consider a nautical mile to be 6000 feet (as opposed to 6080 feet) and approximate the factor 2 (π) to be 6 (instead of 6.283). In addition, the vertical distance labled d in the figure is assumed to approximate the arc of the circumference between the two horizontal lines. Going through the math,

d= 1/360 of the circumference of the circle for each degree of pitch change

Circumference = $2(\pi)r$ = $(2)(\pi)(60)$ = 360 NM

d = (1/360)(360) = 1 NM per degree of pitch change per 60 NM

This means that d is equal to 6000 feet in 60 NM or 100 feet per nautical mile in a no wind situation. Compensating for winds will be discussed later in this chapter. For now, simply remember that a pitch change of 1 degree will result in a climb or descent of 100 feet per nautical mile regardless of airspeed or type of aircraft.

Applying the Rule to Climbs and Descents

To use this information, the pilot needs one more piece of information: a means of checking the performance of the aircraft after the pitch change. Air Force Manual 51-37 indicates the aircraft mach meter reading multiplied by 10 gives a rough idea of airspeed in nautical miles per minute. For example, at 0.7 mach, the aircraft is traveling approximately 7 nautical miles per minute. If the pilot multiplies the pitch change in feet per nautical mile, by the speed in nautical miles per minute, the vertical velocity in feet per minute is obtained. Thus, a performance instrument (the VVI) can be used to determine if the initial pitch change was correct. Note, however, this VVI reading will change with the airspeed (or mach in this case) so that a constant gradient climb or decent will result in a constantly changing VVI reading. The pilot could easily check the descent periodically by repeating the calculations.

For example, assume a pilot wishes to maintain a descent gradient of 350 feet per nautical mile so makes a pitch change of approximately 4 degrees. If the aircraft was traveling at 0.6 mach, what should the Vertical Velocity Indicator (VVI) read initially?

The aircraft is traveling approximately 6 nautical miles per minute. Six nautical miles per minute multiplied by 400 (350 rounded up) feet per nautical mile should result in an initial VVI reading of 2400 feet per minute.

Suppose the VVI had read only 1800 feet per minute. This indicates that only a 3 degree pitch change was made and the desired gradient of 350 feet per nautical mile will not be attained. (1800 feet per minute divided by 6 nautical miles per minute equals 300 feet per nautical mile)

Another good technique is to monitor the altitude loss (or gain) per mile by monitoring the altimeter and the DME readout when preceeding to or from a TACAN. This method will quickly indicate if the desired gradient is being maintained. If not, it is probably because the flight level winds are effecting the flight path. Remember, all calculations up to now have been for a "no wind" condition.

Figure 3-2 shows a 3 degree descent gradient with no wind. As expected, the aircraft loses 300 feet each mile and though the VVI constantly changes as the airspeed changes, the desired gradient is maintained.

Figure 3-3 however, is the same descent except for the addition of 60 knots of tailwind. Although the aircraft is still descending 300 feet per mile through the air, the air mass is moving to the right so the aircraft covers more ground and the actual descent gradient relative to the ground is less. Over the years pilots have developed a rule of thumb of simply changing their attitude 1 degree for every 60 knots of wind. Thus, with a 60 knot tailwind, increase the attitude change by 1 degree.

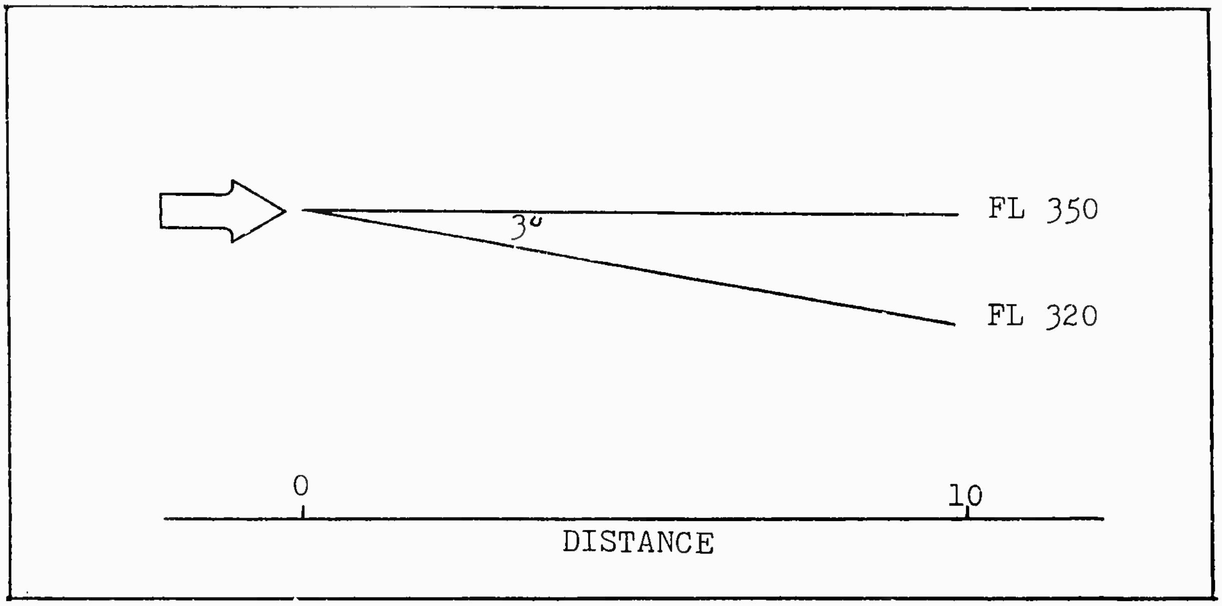


Figure 3-2. Descent Flight Path; No Wind

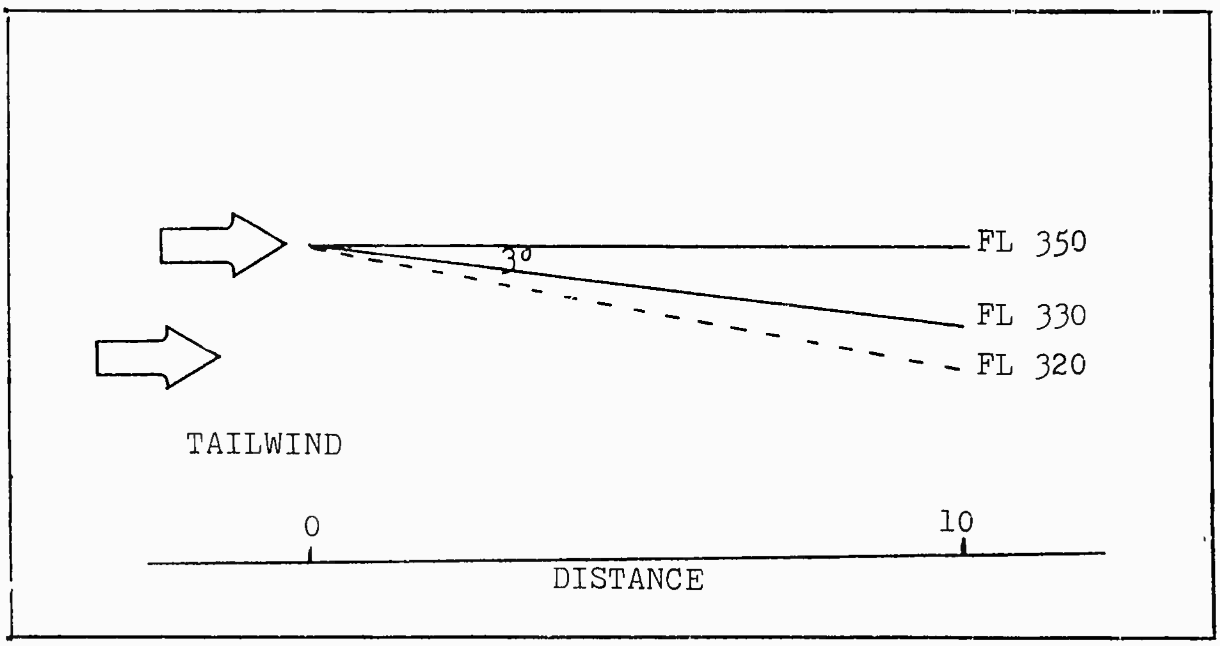


Figure 3-3. Descent Flight Path; With Tail Wind

Using the Rule to Calculate Offsets

The sixty to one rule can also be utilized in the horizontal plane. A good example of its use is for a teardrop holding pattern entry.

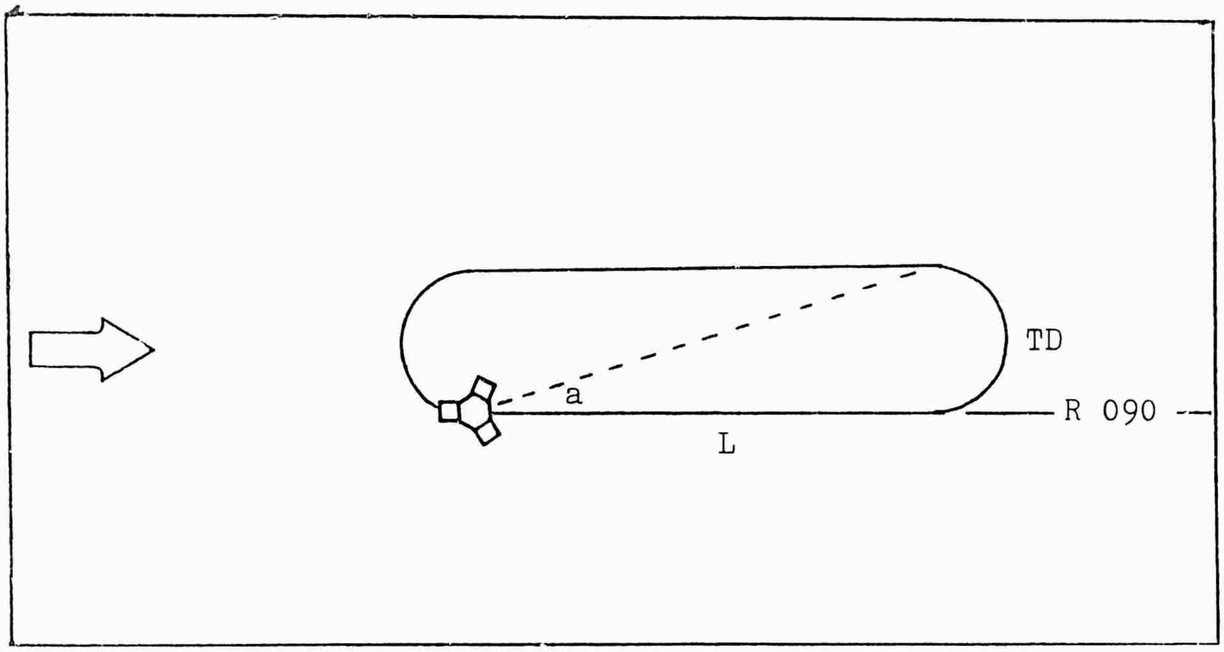


Figure 3-4. Holding Pattern Entry Example

Figure 3-4 depicts a holding pattern a pilot intends to enter from the west, using a teardrop entry procedure. After crossing the holding fix, the pilot could legally fly any heading (course, with course guidance) up to 45 degrees from the holding radial on the holding side. Using the sixty to one rule, the pilot could determine a heading that will offset the aircraft the proper distance from the inbound course to allow a roll out on course at the completion of the turn inbound.

Assuming a true airspeed of 240 knots, the pilot knows the aircraft will travel about 4 NM per minute and the turn radius will be about 2 NM. (Mach would be 0.4 and turn radius is approximately mach times 10 minus 2) Therefore, the aircraft will travel about 6 NM outbound in 1 and 1/2 minutes. The pilot wants to be a turn diameter (4 NM) from the inbound course at the end of the outbound leg. Going through the numbers results in the following relationship:

$$\frac{a}{360} = \frac{TD}{\text{CIRCUMFERENCE}}$$

$$a = \frac{(360)TD}{\text{CIRCUMFERENCE}}$$

$$a = \frac{(360)TD}{(2)(\pi)(L)}$$

Where *a* is the angle of offset, *TD* is the turn diameter of the aircraft in miles, and *L* is the length of the outbound leg in miles. Since $(2)(\pi)$ is approximately 6, the above expression can be simplified to:

$$a = \frac{(TD)(60)}{(L)}$$

In this example:

$$a = \frac{(4)(60)}{(6)} = 40 \text{ degrees}$$

To simplify the whole procedure , multiply the aircraft turn diameter (TD) by 60 and divide the answer by the inbound leg length. The answer will be the offset heading in degrees. In this case, the pilot should turn 40 degrees to the left upon station passage, time outbound for 1 and 1/2 minutes, (apply drift) and make a 30 degree bank turn inbound. This should put the aircraft very close to, if not on, the inbound course.

Summary

This concludes the chapter about the sixty to one rule. It began with a discussion of the theory and derivation of the rule. Application of the rule to climb and descent gradient problems was then discussed. Finally, using the rule to calculate headings to establish offsets for teardrop holding pattern entries and mission planning was described. The sixty to one rule is a very useful tool and should be a part of every professional flier's bag of tricks. When properly used, it can greatly improve a pilot's instrument flying by providing target pitch attitude changes for various instrument maneuvers.

REVIEW EXERCISES

3-1. A pilot is returning to home station after a training mission and is currently 200 NM from the base at flight level 350. The pilot has planned for a 3 degree enroute descent, and wishes to be at 3000 MSL (pattern altitude) 15 NM from the field;

a. Where will the pilot begin the descent?

b. What descent gradient should the pilot hold?

c. What will be the initial pitch change? (no wind)

d. If the pilot was traveling at 0.6 mach, what will be the initial VVI reading?

3-2. The pilot in Problem 3-1 is descending through Flight Level 250 and is informed by ARTCC of traffic at 12 o'clock. Center requests the aircraft be at or below FL 200 in 10 NM.

a. What pitch attitude (reference level flight) will the pilot require? (no wind)

b. If the aircraft was experiencing a 60 knot tail wind, what pitch adjustment could the pilot make to compensate for the wind.

3-3. An aircraft is 80 miles from home station at the completion of a training mission when Center advises the pilot that RAPCON has lost all power and cannot accept any aircraft at this time. Center clears the aircraft to proceed direct to the YUCCA VOR at FL 200 to hold as published (see Figure 3-5). The pilot decides to use a teardrop entry. The aircraft is traveling at 0.4 mach and the pilot plans on traveling outbound for 1 and 1/2 minutes. Winds are light and variable. What outbound heading could the pilot use to enter holding?

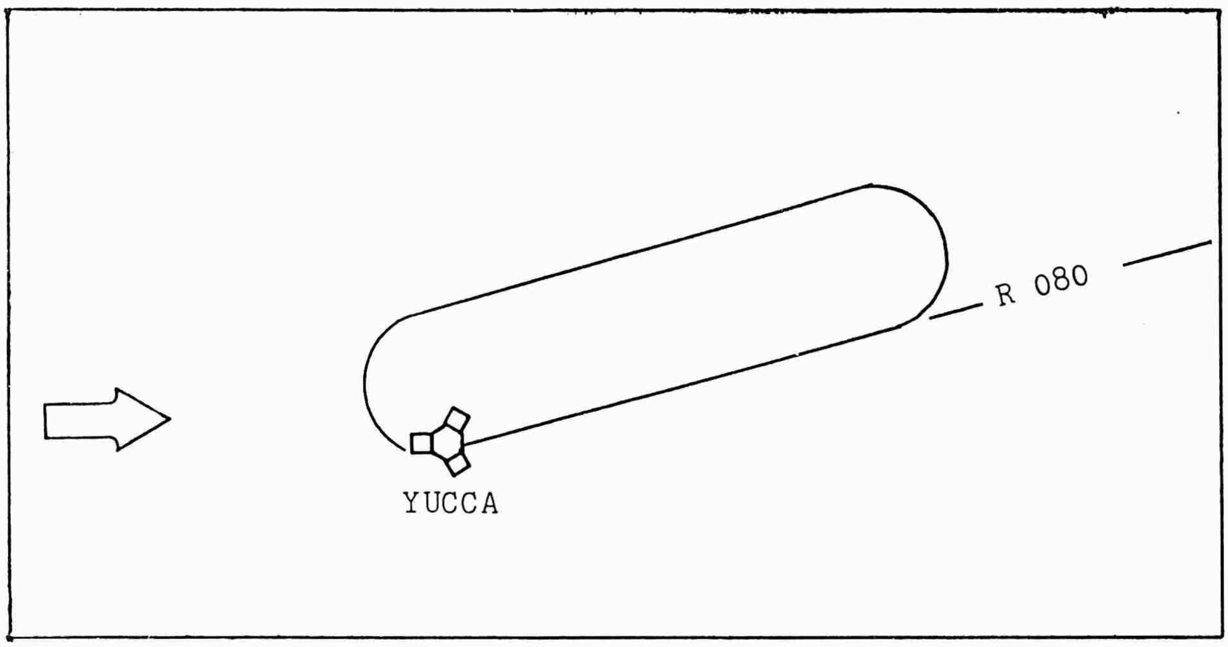


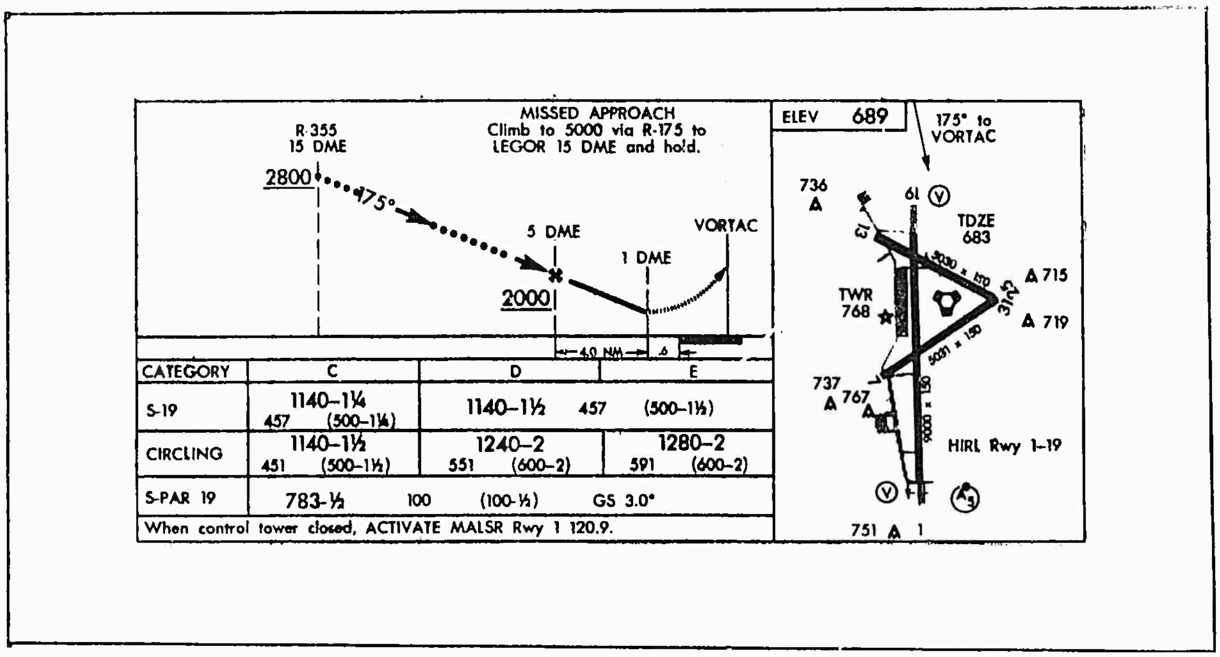
Figure 3-5. Holding Pattern Entry Exercise

3-4. A pilot is flying the TACAN approach shown in Figure 3-6.

a. What minimum pitch change should the pilot make at the FAF?

b. Assuming a True Airspeed of 180 knots, what VVI should the pilot expect?

c. If the minimum pitch change is made, where will the aircraft be when reaching the MDA?



CATEGORY	C	D	E
S-19	1140-1¼ 457 (500-1¼)	1140-1½ 457 (500-1½)	
CIRCLING	1140-1½ 451 (500-1½)	1240-2 551 (600-2)	1280-2 591 (600-2)
S-PAR 19	783-½ 100 (100-½) GS 3.0°		

When control tower closed, ACTIVATE MALSR Rwy 1 120.9.

Figure 3-6. Descent Gradient Exercise

Chapter Four

ARTCC PROCEDURES

OBJECTIVES

At the completion of this lesson the pilot will:

1. Be able to describe the information flow process that occurs during the submission, processing, and issuance of a typical Instrument Flight Rule (IFR) flight clearance.
2. Be familiar with the information available to a typical Air Route Traffic Control Center (ARTCC) controller to control air traffic.
3. Understand the services available, limitations, and task priorities of a typical ARTCC controller.
4. Be familiar with the pilot procedures anticipated by an ARTCC controller in the event of loss of communications between the controller and an aircraft.

REVIEW MATERIAL

Introduction

Current directives specify all Air Force pilots will utilize Instrument Flight Rule (IFR) procedures to the maximum extent possible. This necessitates close coordination between pilots and Air Route Traffic Controllers on an almost daily basis. Although most pilots are very comfortable working and communicating with ARTCC, some do not understand the procedures, services, and limitations involved. This chapter begins with a discussion of the information flow necessary to process and deliver an IFR clearance to an aircraft both prior to takeoff and while airborne. The information available to an air traffic controller is then described and some of the services available, limitations to these services, and controller task priorities are then discussed. Anticipated pilot procedures in the event of lost communications between a controller and an aircraft are then illustrated. The chapter concludes with a summary and a selection of review questions to allow pilots to assess their knowledge of ARTCC operations and services.

Processing an IFR Clearance

Since most USAF pilots file and fly using IFR flight plans, a through understanding of how a requested route of flight and other pertinent information is submitted, processed, and approved can allow a pilot to better utilize the system. This section describes the information flow in the clearance process.

Processing an IFR flight plan normally begins at Base Operations and usually consists of pilot submission of a D D Form 175 and a crew/passenger listing. Often, a SAC Form 207 is also submitted if the flight plan is too long to fit on a D D Form 175. The dispatcher enters some of the information contained on this paperwork directly into the ARTCC computer system. Items such as the aircraft tail number, hours of fuel on board, alternate airfield, flight time to the alternate, pilot's name, ground distance to destination, and the aircraft unit of assignment, are not transmitted to ARTCC. If the aircraft is departing a civilian airfield, a flight service station will submit the flight plan information subject to the same limitations.

When the flight plan is submitted, the ARTCC computer will check each point and reject the flight plan if it finds improper identifiers or NAVAID fix information. For example, fixes differing from those published for Air Refueling tracks or Low Level entry and exit points will be rejected. Thus, even if a selected NAVAID is known to be out of service, the published fixes must still be filed or the flight plan will not be accepted by the computer. Once verified and entered into the ARTCC system, the flight plan will remain in the computer for up to two hours after the proposed departure time unless extended by changing the proposed departure time.

The next step in the process occurs approximately 30 minutes prior to scheduled departure. At this time, the clearance is automatically printed out in the base clearance delivery or departure control facility at bases possessing the required equipment. At most locations, it is also printed out in the tower. If departing from a civilian facility, the pilot may have to receive the clearance from clearance delivery, a local flight service station (FSS) by radio or telephone; or, if practicable, take off under VFR conditions and request the clearance from FSS or ARTCC after airborne. Once the aircraft is airborne, the tower notifies Base Operations of the actual takeoff time. If the aircraft is landing at other than the departure base, Base Operations personnel send a flight notification message to the destination either directly or through FSS, depending on the communications system in use. If the aircraft is returning to the departure base, Base Operations personnel simply note the takeoff time and the expected arrival time in their log.

In some cases, a pilot will take off with a valid flight plan and due to mission changes or hazardous weather, be forced to change the route of flight while airborne. This is not difficult and can be done in several ways. The two most common methods of changing a flight plan while airborne are through ARTCC or through FSS.

If a pilot can transmit the requested flight plan change directly to ARTCC the information flow and processing are somewhat simplified. In this case, an ARTCC controller will input the requested route directly into the ARTCC computer system. Once this is done, and the computer has verified and accepted the routing, the controller will amend the pilot's clearance and the process is almost complete. Remember, the pilot must also update any other changes such as the ETE or amount of fuel on board with the SAC command Post and the FSS which services the departure base. In some cases, however, an ARTCC controller may be too busy or unable to accept a flight plan change and the pilot must utilize a different procedure.

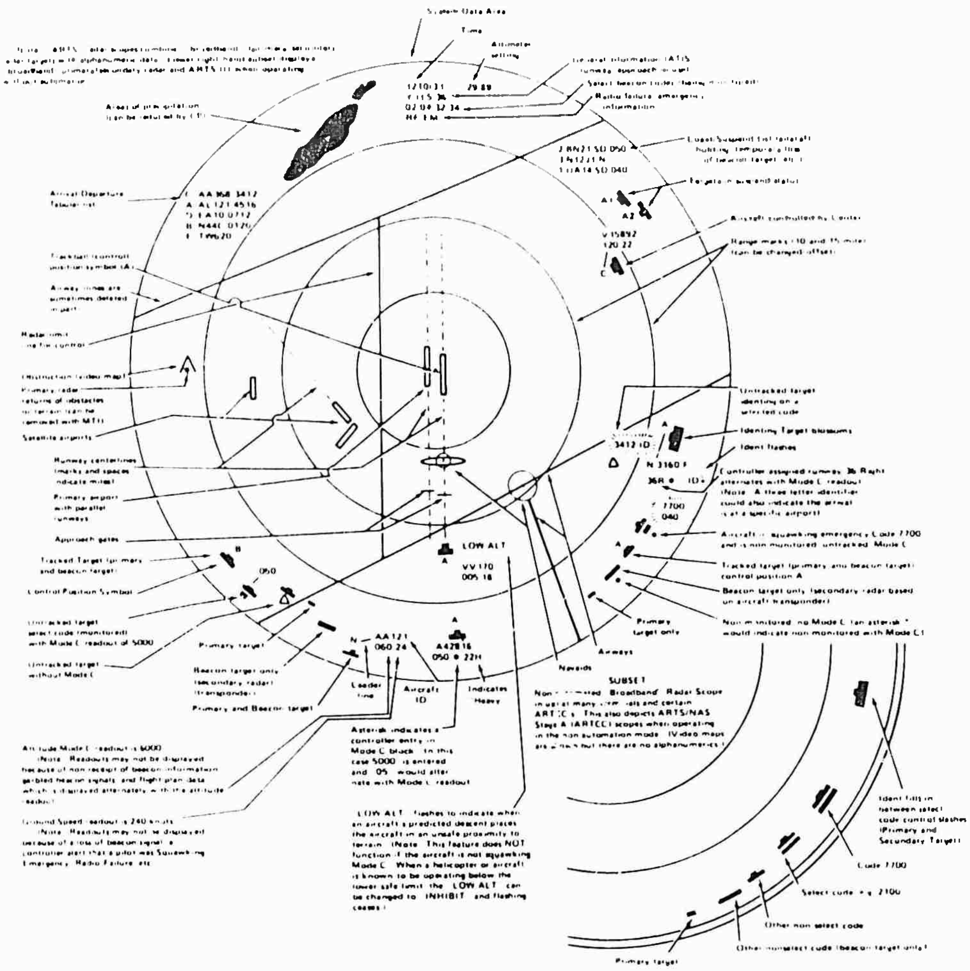
If ARTCC cannot accept a flight plan change, the pilot should work through a FSS. In this case, a pilot must transmit the requested route change to a flight service station. The FSS operator then inputs the requested route into the ARTCC computer system. Note however, receipt of the requested changes and even input into the computer system does not change the pilot's original clearance. Once the requested route has been accepted by the computer and the clearance modified, the pilot could be notified by one of two methods. One method is through ARTCC directlv. The other is through the FSS which input the requested changes. Either method will suffice, however, many pilots prefer to receive their clearance directly from ARTCC; thus eliminating the FSS operator and a possible source of confusion in the information flow process. This completes the discussion of the information flow with the exception of closing the flight plan.

Once an aircraft has terminated a flight, the flight plan must be closed. Current directives require that a pilot verbally verify the closure of the flight plan with tower or Base Operations personnel. At military fields, this is a back up procedure since Base Operations personnel normally close a flight plan upon landing notification from tower. At a civilian field, a pilot must close the loop through FSS either by radio prior to landing, or by radio or telephone after landing.

ARTCC Facilities

Under normal conditions ARTCC controllers can use their facilities and experience to provide many extra services to a pilot. Many of these are a direct result of the modern equipment in use today. This section discusses the equipment used, the information available to a controller, and the services this information allows.

Modern ARTCC facilities utilize one of several types of radar scope displays. The basic radar presentation shown in Figure 4-1 is provided by a scope known as the ARTS III. It consists of primary targets, or radar energy reflected from an aircraft, secondary targets, which consist of radar energy transmitted by the aircraft transponder, some ground returns, heavy precipitation, and alphanumeric data. The additional



ARTS III Radar Scope with Alphanumeric Data. Note: A number of radar terminals do not have ARTS equipment. Those facilities and certain ARTCC's outside the contiguous US would have radar displays similar to the lower right hand subset. ARTS facilities and NAS Stage A ARTCC's, when operating in the non automation mode would also have similar displays and certain services based on automation may not be available.

Figure 4-1. ARTS III Radar Depiction

information provides a controller with the location of obstructions, local airports, and certain aircraft identification features for secondary targets.

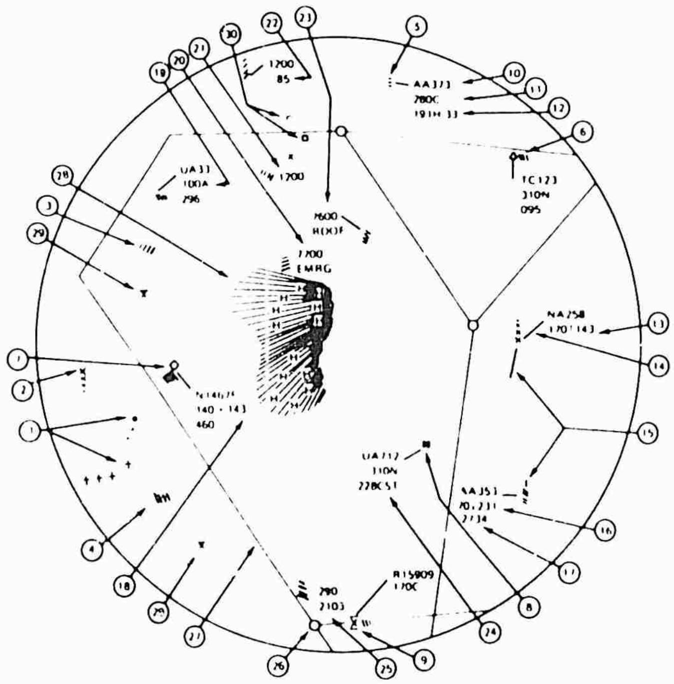
A typical secondary radar target consists of a rectangular shaped mark at the aircraft position, a computer generated identification line, an altitude readout (if the aircraft has an operating mode C transponder and the center is equiped to display the altitude), and the assigned transponder mode 3 setting. In addition, many radars will display a flashing "Low Altitude" warning if the computer determines the aircraft altitude, as reported by the mode C, places the aircraft in unsafe proximity to the ground. Some radars will flash the aircraft identification line to indicate a possible conflict in air traffic. The "Ident" mode of a transponder may show up in several ways, such as an enlarged target or a flashing target, depending on the equipment in use.

Heavy precipitation will show on a radar scope as a dark area. This dark area can be greatly reduced by using a feature called Circular Polarization. Controllers using this feature may not observe all the precipitation in the area of radar coverage. It is important that pilots understand this limitation and be alert for unreported hazardous weather. In most ARTCC facilities circular polarization is selectable and a controller may be willing to disable this feature to provide additional weather information to a pilot if requested.

A basic radar presentation will also normally depict the position of high obstructions, local airfields, and airways or jet routes running through the area of coverage. In some areas, this additional information allows the controller to provide vectoring service. The controller is provided with minimum vectoring altitudes based on the known obstructions. These altitudes will vary with the section of controlled airspace the aircraft is in but will assure safe terrain and obstruction clearance.

A second type of radar presentation, known as NAS Stage A, is shown in Figure 4-2. This radar presentation is a digitized display of radar information and not raw radar data. The presentation contains basically the same information as the ARTS III with certain modifications and additions.

Aircraft symbology is slightly different on the NAS Stage A. For example, a primary return is shown as a plus sign, a dot, or an X while a secondary return is depicted as a slash with identification data. This identification line contains the aircraft call sign, assigned altitude and mode C altitude readout if the aircraft is so equiped, and a computer identification number. The scope will display two additional slashes beside the aircraft position to depict a transponder "Ident". An emergency mode 3 code setting of 7700 or a radio failure setting of 7600 will show as additional notation to alert the controller, as shown in Figure 4-2, items 20 and 23. In some facilities, a code of 7700 or selecting emergency on the transponder will also activate an alarm.



Target Symbols

1 Uncorrelated primary radar target + ●
2 *Correlated primary radar target x
3 Uncorrelated beacon target /
4 Correlated beacon target \
5 Identing beacon target ■
(*Correlated means the association of radar data with the computer projected track of an identified aircraft)

Position Symbols

6 Free track (No flight plan tracking) △
7 Flat track (flight plan tracking) ◊
8 Coast (Beacon target lost) #
9 Present Position Hold X̄

Data Block Information

10 *Aircraft Identification
11 *Assigned Altitude FL 280, mode C altitude same or within 1200' of asgnd altitude
12 *Computer ID #191, Handoff is to Sector 33 (0-33 would mean handoff accepted) (*Nr's 10, 11, 12 constitute a "full data block")
13 Assigned altitude 17,000', aircraft is climbing, mode C readout was 14,300 when last beacon interrogation was received
14 Leader line connecting target symbol and data block
15 Track velocity and direction vector line (Projected ahead of target)
16 Assigned altitude 7000, aircraft is descending, last mode C readout (or last reported altitude was 100' above FL230
17 Transponder code shows in full data block only when different than assigned code
18 Aircraft is 300' above assigned altitude
19 Reported altitude (No mode C readout) same as assigned. An "N" would indicate no reported altitude)
20 Transponder set on emergency code 7700 (EMRG flashes to attract attention)
21 Transponder code 1200 (VFR) with no mode C
22 Code 1200 (VFR) with mode C and last altitude readout
23 Transponder set on Radio Failure code 7600, (RDOF flashes)
24 Computer ID #228, CST indicates target is in Coast status
25 Assigned altitude FL290, transponder code (These two items constitute a "limited data block")

Other symbols

26 Navigational Aid
27 Airway or jet route
28 Outline of weather returns based on primary radar (See Chapter 4, ARTCC Radar Weather Display. H's represent areas of high density precipitation which might be thunderstorms. Radial lines indicate lower density precipitation)
29 Obstruction
30 Airports Major [] , Small (

NAS Stage A Controllers View Plan Display. This figure illustrates the controller's radar scope (PVD) when operating in the fu automation (RDP) mode, which is normally 20 hours per day (Note: When not in automation mode, the display is similar to the broadband mod shown in the ARTS III Radar Scope figure. Certain ARTCC's outside the contiguous U.S. also operate in "broadband" mode.)

Figure 4-2. NAS STAGE A Radar Depiction

Areas of precipitation are also illustrated differently on the NAS Stage A radar. Since the display is a digital representation of the actual data, precipitation would not be visible. Therefore, the computer presents areas of precipitation as a series of lines with the letter "H" depicted at the locations of the heaviest density precipitation. Thus, the controller's ability to observe hazardous weather is often limited.

An additional feature available with the digitized radar is the projected flight path of an aircraft. Upon request, the computer is capable of depicting an aircraft's route of flight through the controller's area of responsibility and will also generate a projected flight path based on present course. Thus, a controller can quickly determine if an aircraft is on course, observe the next filed point, and decide if the aircraft will remain on course based on present heading.

Controller Priorities

ARTCC controllers can assist a pilot in many ways. For example, pilots often utilize controllers to process inflight changes to flight plans, assist in the avoidance of hazardous weather, assist in accomplishing cell and inflight refueling rendezvous, and obtain weather information for landing. This section is a brief description of the guidance provided to the controller to determine which services to provide first or whether to provide these services at all.

The pilot must understand that all controllers are directed to give first priority to maintaining aircraft separation and issuing safety advisories. Current controller regulations, however, caution that because of the many variables and situations involved, it is impossible to publish a standard set of duty priorities that will apply in every situation. Concequently, controllers are instructed to evaluate each situation individually and exercise their best judgement. Additional services may be provided contingent upon such factors as workload and frequency congestion.

In general, services involving aircraft control and safety receive the highest priority. For example, terrain and aircraft avoidance advisories, Sigmets, and Airmets are broadcast before less time sensitive requests. Duties such as relaying PIREPS, assisting aircraft navigation through hazardous weather, and notifing pilots of reported bird concentrations are not as critical, but will be handled as expediously as possible. Other services, such as relaying altimeter settings, providing landing weather, and accepting flight plan changes are of a lower priority and will be accomplished as time permits.

Controllers are also instructed as to priority for operational aircraft. As might be expected, aircraft in distress have priority over all other aircraft. After that, controllers handle aircraft on a first come, first serve basis with a few exceptions. For example, civilian ambulance flights and military air evacuation flights generally receive the next highest priority, closely followed by Search and Rescue (SAR) aircraft. Controllers are instructed that unexpected weather or heavy traffic flows may preclude these priorities, and that their decisions as to which services to provide need not be explained to pilots. Therefore, a pilot must be prepared to work with the controller to assure a safe environment in which to fly.

Lost Communications Procedures

This section examines lost communications procedures from the controller's point of view. It is intended to expand upon the procedures published in the Flight Information Handbook (FIH) and current Air Force publications. It is based on FAA regulations used by controllers and conversations with experienced air traffic controllers. Remember, as with other flight procedures, if confronted with a situation not discussed in current regulations, controllers expect the pilot to use good judgement and will base their actions on anticipated pilot actions.

If communications are lost with an aircraft on an IFR flight plan, the controller's actions will be based on certain anticipated pilot actions. For example, the controller expects the pilot to follow the flight plan and verify radio failure by changing the mode 3 transponder setting to 7700 for 15 minutes and then to 7600 for the remainder of the hour, repeating this procedure each hour until the flight is terminated. The controller also expects the pilot to land when practicable. This is not to be confused with as soon as possible and should not encourage pilots to land at an unsuitable airfield or short of the destination.

The controller will always attempt to contact the aircraft using alternate methods. For example, VHF equipped aircraft can expect controllers to attempt contact on VHF frequencies, including 121.5 MHz. UHF Guard frequency (243.0) may also be utilized, as well as flight service frequencies. In addition, pilots should monitor VOR frequencies along the route of flight since some NAVAIDS are equiped for voice transmission. Pilots receiving ARTCC instructions, but unable to reply, may be directed to place their transponder in "standby" or "ident" as a means of acknowledging transmissions. If contact cannot be made or maintained, the controller will clear airspace accordingly. A controller's actions will be slightly different if the aircraft is in the traffic pattern when communications are lost.

Once an aircraft is in the traffic pattern, the pilot should always have a plan for lost communications situations. If IFR conditions exist, the controller will issue lost communications instructions for all radar approaches. If these instructions are not suitable, the pilot should request different instructions. If an aircraft is being vectored to a FAF for a published approach when communications are lost, the pilot is cleared to use the aircraft navigation equipment to find the FAF for any published approach to the active runway. The controller will monitor the aircraft position and clear other traffic as necessary. The controller will also notify the tower, and the pilot should monitor the tower for light signals, weather conditions permitting. Most bases publish local procedures which supplement the general guidance so a pilot should always be familiar with any local directives if possible.

Summary

This chapter has reviewed some of the procedures and services provided by a typical ARTCC facility. It began with a discussion of the information flow involved with filing, processing, and delivering an IFR clearance. The information available to a controller was then described. Controller priorities and lost communications procedures were then discussed. All Air Force pilots can expect to work closely with ARTCC in most of their daily flight operations. Thus, a strong understanding of the controller's limitations and guidance is vital if the pilot is to obtain the maximum benefits and operate the aircraft safely.

REVIEW EXERCISES

4-1. When flying out of a Military airfield is it necessary to request Ground Control or Clearance Delivery to place the "clearance on request"?

4-2. At a military airfield, what office is responsible for transmitting a flight notification message if one is required?

4-3. Is it possible for an ARTCC controller to observe hazardous weather on a radar scope?

4-4. What happens in an ARTCC facility when a pilot selects "emergency" or sets code 7700 in the mode 3 of the aircraft transponder?

4-5. Upon what will the actions of a controller be based when confronted with a lost communication situation not covered by regulations?

ANSWERS TO REVIEW EXERCISES

1-1. a. 037 MH
b. 100 NM
c. 20 minutes

1-2. Aircraft will burn 30,000 pounds of fuel in 90 minutes and will thus have 55,000 pounds of fuel remaining.

1-3. The pilot can burn 55,000 pounds of fuel and depart with 35,000 pounds of fuel. At 18,000 pounds per hour, the pilot can hold for approximately three hours.

1-4. The aircraft must lose 1020 feet in 3.7 Nautical Miles. This requires a descent of 276 feet per nautical mile.

1-5. The answer depends on the rate of descent the pilot choses to use to descend from the MDA at the VDP to the runway. Assuming a 3 degree descent, the pilot will descend 457 feet (1140 - 683) in appproximately 1.5 NM. Therefore, the VDP must be 1.5 NM from the end of the runway. The TACAN is 0.4 NM from the end of the runway (1 - 0.6) so the VDP should be at 1.9 DME. (1.5 + 0.4). The distance from the FAF to the VDP is 3.1 NM (5 DME - 1.9 DME). At 180 knots ground speed, this will require 62 seconds. The distance from the FAF to the MAP is 4 NM. At 180 knots ground speed this will require 80 seconds.

2-1. 327 TH - 8 Variation = 319 MH

2-2. Most alert areas and their hours of operation are listed in FLIP. A pilot could also obtain the current status of the area from the controlling agency (ARTCC).

2-3. a. See figure 5-1.
b. See figure 5-1.
c. See figure 5-1.
d. 45 minutes

3-1. a. The pilot wishes to lose 32,000 feet at 300 feet per nautical mile. This descent will require 107 nautical miles. Since the pilot wishes to be level at 3000 MSL at 15 DME, the descent should begin at 122 DME.

b. 300 feet per nautical mile.
c. 3 degrees from level flight
d. 1800 FPM.

3-2. a. The pilot wants to lose 5000 feet in the next 10 nautical miles. This descent would require a 5 degree pitch change.

b. The pilot would make an additional 1 degree pitch change (for a total of 6 degrees) and monitor the progress of the descent.

3-3. A heading to establish an offset distance of one turn diameter from the inbound course could be established by multiplying the aircraft turn diameter by 60 and dividing the answer by the length of the inbound leg in nautical miles. In this case, (4)(60)/(6)=40 degrees. The pilot could turn to 040 degrees plus or minus drift, although any heading between 035 and 080 would be legal IAW AFM 51-37.

3-4. a. The pilot wishes to lose 860 feet (2000 - 1140) in 4 nautical miles. This rate of descent requires a descent of 215 feet per nautical mile. Therefore, the pilot should make at least a 2.5 degree pitch change.

b. 750 FPM. (3 NM/Min)(250 Ft/NM)

c. At this rate of descent, the aircraft will be at the MAP when reaching the MDA and possibly past the pilot's preferred VDP.

4-1. Not normally. Most military facilities have the equipment to automatically print out a pilot's clearance thirty minutes prior to expected departure time.

4-2. Base Operations personnel.

4-3. Yes. The degree to which hazardous weather will show depends on the type of radar equipment installed and whether or not circular polarization is in use.

4-4. The answer depends on the equipment in use and varies from a flashing ID line to an enlarged return. At some facilities, an alarm may also be activated.

4-5. Anticipated pilot actions and the pilot's last clearance.

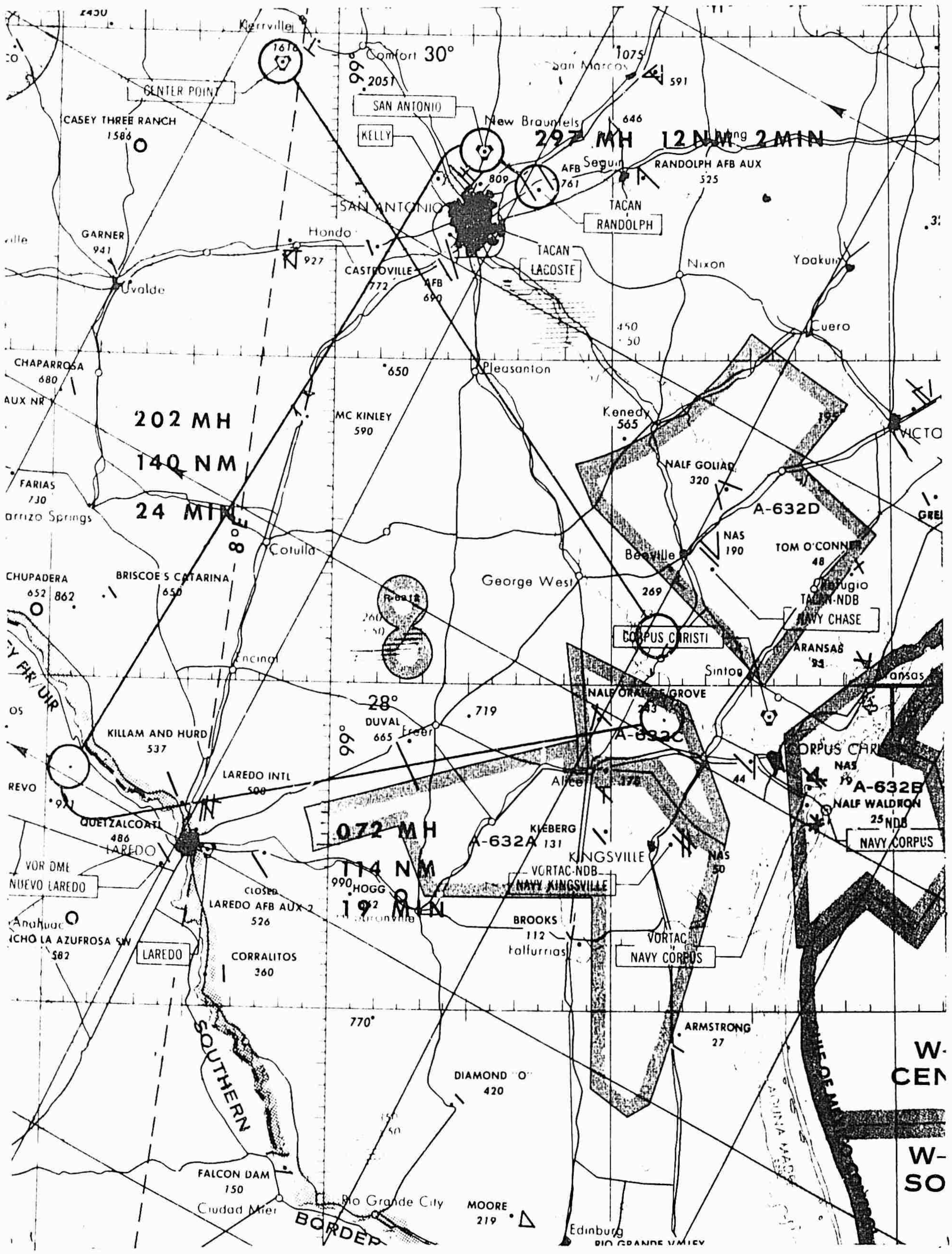


Figure 5-1. Sample Pilot Chart

BIBLIOGRAPHY

REFERENCES CITED

Articles and Periodicals

1. Sams, Ronald., Maj, USAF, "Descents ... The Easy Way." Combat Crew, August 1983, pp 7,24.

2. Walters, Thome H. Jr., Capt, USAF, "Big Instrument: 60 To 1 Rule." Combat Crew, March 1979, pp 19-21.

Official Documents

3. Defense Mapping Agency Aerospace Center. DOD Flight Information Publication (Terminal) NE, High Altitude United States. St. Louis: Defense Mapping Agency Aerospace Center, 20 December 1984.

4. U.S. Department of the Air Force. Air Navigation. AF Manual 51-40. Washington, D.C. : Government Printing Office, 15 March 1983.

5. U.S. Department of the Air Force. Dead Reckoning Computer (MB-4 or CPU-26), AF Pamplet 60-19, Volume V.Washington, D.C.: Government Printing Office, 16 July 1984.

6. U.S. Department of the Air Force. General Flight Rules, AF Regulation 60-16. Washington, D.C.: Government Printing Office, 5 December 1980.

7. U.S. Department of the Air Force. Instrument Flying. AF Manual 51-37. Washington D.C.: Government Printing Office, 15 August 1979.

8. U.S. Department of the Air Force. Navigation For Pilot Training. ATCP 51-16. Washington, D.C.: Government Printing Office, 15 July 1983.

9. U.S. Department of Transportation. Airman's Information Manual. Washington, D.C.: Government Printing Office, 25 October 1984.

CONTINUED

10. U.S. Department of Transportation. Air Traffic Control. Air Traffic Control Handbook 7110.65D. Washington D.C.: Government Printing Office, 25 October 1984.

Other Sources

11. Defense Mapping Agency Aerospace Center. JNC 44 Aeronautical Chart. St. Louis: Defense Mapping Agency Aerospace Center, Revised November 1982.

12. Carter, William., Air Field Manager, Maxwell AFB, Al. Interview with Author, 7 January 1985.

13. McUmber, Warren..Air Traffic Control Supervisor, Maxwell AFB, Al. Interview with Author. 10 January 1985.

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CONTINUED