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East Joppa Road
Baltimore, Maryland 21204

MIDWEST
Bendix Radio Division
3303 East Harry Street
Wichita, Kansas 67218

WEST COAST
Bendix Radio Division
16509 Saticoy Street,
Van Nuys, California 91406

SOUTH
Bendix Radio Division
4471 N.W. 36th Street,
Miami, Florida 33166

INTERNATIONAL
Bendix International Operations
605 3rd Avenue,
New York, New York 10016

CANADA
Computing Devices of Canada Limited
P.O. Box 508,
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Aviation Electric Pacific Limited
Vancouver Airport,
Vancouver, B.C.

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Printed in U.S.A. 766

ACS 522

Pilot's Manual

TROPHY LINE

ADF-T-12C Automatic Direction Finder

Bendix Radio Division
AVIONICS PRODUCTS • BALTIMORE, MARYLAND 21204

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NOTES:

Bendix ADF-T-12C

PILOT'S INSTRUCTION MANUAL

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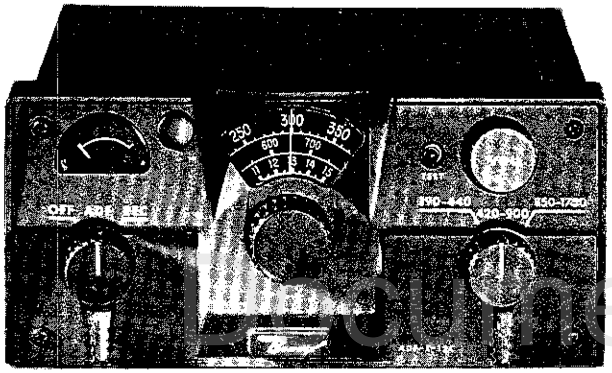
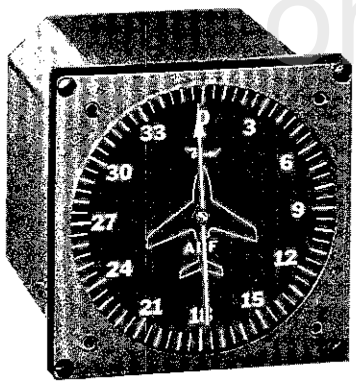
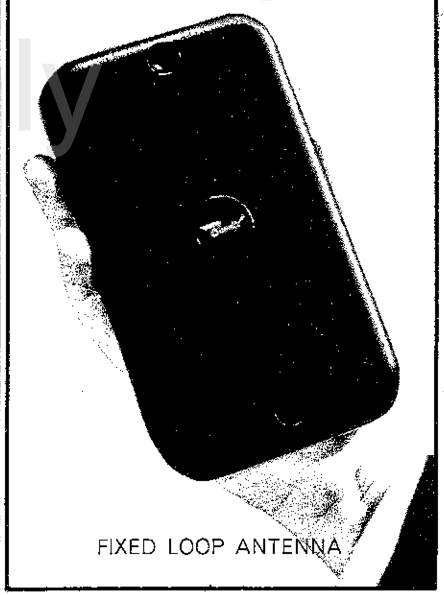
BENDIX ADF-T-12C SYSTEM



RECEIVER



DIRECTION INDICATOR



FIXED LOOP ANTENNA

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CAUSES OF ERRONEOUS ADF BEARINGS AM BROADCAST STATION INTERFERENCE Frequency spacing of stations in the AM broadcast band is such that transmissions from different stations may overlap or interfere with one another. Many frequencies are used by two or more stations. Always make an absolute identification of an AM broadcast station before using it for navigational purposes.

IMPROPER TUNING Always tune to the center of any received signal. Tuning in the fringes of a signal may give erroneous bearings.

ELECTRICAL STORMS In the vicinity of electrical storms, the direction indicator pointer tends to swing from the radio station tuned in to the center of the storm. The location of the storm is useful information, but the erratic behavior of the indicator makes it difficult to obtain reliable bearings.

NIGHT EFFECT Night effect is a disturbance which is particularly strong immediately after sunset and just before dawn. The indicator pointer may swing erratically at these times. Tuning in the most powerful stations at the lowest frequencies possible will minimize night effect. When a station which is causing pointer oscillation must be used, take an average reading of the oscillations to determine the relative bearing.

MOUNTAIN EFFECT Erroneous or fluctuating bearings may result from the reflection of radio waves from the surface of mountains. Use caution when taking bearings over mountainous terrain.

COASTAL REFRACTION Radio waves may be refracted when passing from land to sea or when moving parallel to the coastline. Be aware of the possibility of receiving erroneous signals.

PRE-FLIGHT CHECKING The following pre-flight check procedure should be performed prior to take-off to assure accurate equipment operation.

1. Position the aircraft on a known true heading such as a line parallel to a runway.
2. Consult the chart and select a station approximately 50 miles from the field that provides a strong signal.
3. From the chart note the bearing of the station from the airport relative to the true heading.
4. Turn the function switch to REC. While watching the tuning meter for maximum signal, tune in and identify the selected station. Turn the function switch to the ADF position and observe the pointer swing and point to the selected station.
5. Press the test button and observe the pointer move away from the relative bearing. After the pointer has moved through approximately 45 degrees, release the test button and observe the pointer return to the relative bearing. Sluggish return or no return indicates a malfunctioning system.
6. Compare the bearing displayed on the indicator with the bearing determined from the chart. If the bearings agree, the equipment is in proper working order.

NOTE: Metal hangars, electrical leads to runway lights, and radio transmitters close by may disturb the ADF reading. During a pre-flight check, keep a considerable distance away from these objects.

ADF NAVIGATION TIPS To effectively utilize the ADF you should be familiar with the characteristics of the many radio stations in the ADF frequency range. The following discussion and definitions of standard abbreviations provide a reference to important ADF radio navigation aids.

COMMERCIAL BROADCAST STATIONS operate in the 550 to 1600 kilocycle range. These stations can be used for homing, position fixes, and time-distance checks. However, caution should be exercised when tuning these stations as they are not associated with specific airports and operation may not be continuous or at a constant power level. Positively identify the station before homing. This may be difficult as commercial stations identify themselves at infrequent intervals.

LOW-FREQUENCY AND MEDIUM-FREQUENCY RANGE STATIONS include the following classes:

RA — Range Adcock, power 150 watts or more.
RL — Range Loop, power 150 watts or more.
The above stations are among the most powerful and can be received at long distances.
ML — Range Loop, power less than 50 watts.
MRA — Range Adcock, power from 50 to 150 watts.
MRL — Range Loop, power from 50 to 150 watts.
These stations are less powerful than the RA—RL class.

All Adcock range stations (RA and MRA) have simultaneous voice and range signal transmissions. Loop stations with simultaneous transmissions have an identifying letter "S" (SMRL).

FAA RADIO BEACONS operate within the 200-400 kilocycle radio-frequency band. They are located in enroute areas as navigational aids and in the vicinity of airports as instrument approach aids.

Radio beacons are classed as either H, MH, or HH facilities. H facilities have a power output from 50 to 2000 watts, are usually used as airway check points, and operate continuously. MH facilities have a power output of less than 50 watts and may operate continuously or on request. MH facilities are normally used in connection with instrument approaches. HH facilities have a power output of 2000 watts or more.

ILS COMPASS LOCATORS are located at major airports throughout the country and are normally used in conjunction with instrument approach and landing systems. Compass locators operate in the 200-415 kilocycle band, are non-directional stations, and are useful for homing. Normally ILS systems consist of two compass locator stations. The first, the outer marker (LOM), is located approximately 4.5 miles from the ILS runway. The second, the middle marker (LMM), is located about 0.6 mile from the ILS runway. These stations are invaluable aids for locating airports, homing to airports, and for low visibility approaches to the ILS runway.

CONTROL TOWERS may be used as homing stations in an emergency. Ask the tower operator to keep the transmitter operating continuously, and home to the field on this signal.

INTRODUCTION The ADF-T-12C will be a valuable navigation aid in answering your questions "Where am I? Where is the airport or station I wish to fly to? Which direction do I turn to get to the airport?" or "How do I make a controlled letdown and approach to the airport?" In daylight or dark, on or off airways, the ADF will direct you to your destination swiftly and safely. To obtain the best results from the ADF, READ THESE INSTRUCTIONS CAREFULLY. REMEMBER . . . it is impossible to know too much about the correct use of equipment in the aircraft.

Operation of direction finders is based on the fact that radio waves propagate from transmitters along great circle routes. The ADF-T-12C system enables an aircraft to obtain its location by determining the direction of arrival of the radio waves from transmitters in known locations.

The system consists of a fixed-loop antenna, a sense antenna, a receiver with tuning meter, a gonio-indicator (direction indicator), and a servo amplifier. The receiver covers the frequency range of 190 through 1750 kilocycles in three overlapping bands, and is designed for REC or ADF operation. In the REC mode, the receiver uses the sense antenna only and operates as a conventional low-frequency communications receiver. In the ADF mode, the receiver combines signals from the two antennas to form a resultant signal that positions a motor-driven indicator to point in the direction of the transmitter. There is no possibility of so-called "180 degree directional ambiguity" occurring in ADF operation. The direction indicator always points at the source of the signal being received. In the ADF mode, position fixes can be obtained by taking bearings on two or more stations, and plotting the results on an aeronautical chart.

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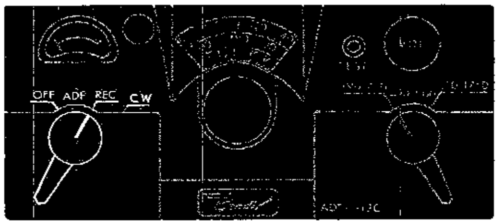
ADF-T-12C SYSTEM DESCRIPTION AND CONTROLS



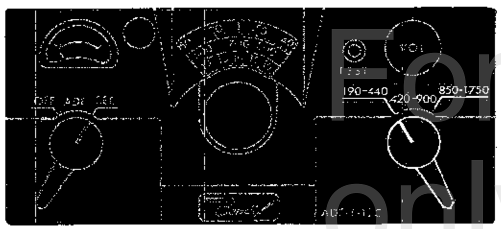
FUNCTION SWITCH

OFF Position—In this position all power is off. Moving the switch to any other position turns the system power on.

ADF Position—Equipment functions as an automatic radio direction finder.

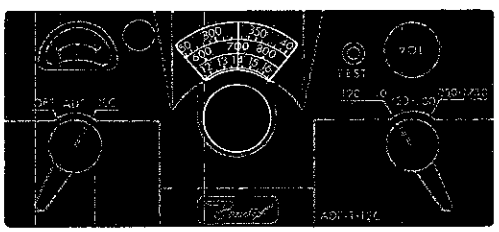
REC Position—Equipment functions as a standard communications receiver. The direction indicator does not operate when the switch is in this position.

CW Position—(Receiver Model D only)—Equipment functions as a communications receiver for the reception of continuous wave transmissions. It may also be used as a tuning aid for weak or distant stations.



BAND SWITCH Selects the desired operating band. The bands and frequency ranges are listed below.

Frequency Range	*Band*
190-440 kilocycles	FAA lower frequency range and tower band.
420-900 kilocycles	Lower range of commercial broadcast band.
850-1750 kilocycles	Upper range of commercial broadcast band.



TUNING CONTROL Tunes the equipment to the desired frequency (station) within the operating band.

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ADF INSTRUMENT APPROACH The ADF, in conjunction with the Magnetic Compass, can be used to perform instrument approach procedures. In this application, the ADF is used initially to locate the Non Directional Beacon (NDB), and subsequently to determine wind drift compensation while flying the Magnetic Compass during the final approach.

NDB's authorized for ADF Instrument Approach are listed in the Airman's Guide, published by the U.S. Government Printing Office, Washington 25, D.C. Instrument Approach Procedure Charts for each authorized NDB are published by the U.S. Department of Commerce, Coast and Geodetic Survey. A typical approach chart is shown in the illustration, and is used in the following explanation to demonstrate the procedure.

As the aircraft approaches the NDB the ADF Indicator will read close to zero depending on wind conditions. When the NDB is reached, the indicator pointer will swing wildly on either side of the 0 degree reading. At this point steer the aircraft until the Magnetic Compass indicates the outbound magnetic heading (238 degrees) shown on the approach chart. Track the outbound magnetic heading, using the Direction Indicator to determine wind drift. In the absence of crosswinds the Indicator will read 180 degrees. In the presence of crosswinds, the Indicator will drift from the 180 degree reading. Correct for crosswinds as detailed on Page 10.

While flying outbound, complete the landing check-off list and descend to the minimum procedure-turn altitude as indicated on the chart. Turn left until the Magnetic Compass reads 193 degrees. Hold this course for the required period of time, depending on wind conditions, then make a standard rate turn to the right. The turn is completed when the Magnetic Compass indicates a heading of 013 degrees. Fly this heading and observe the Direction Indicator. When the Direction Indicator indicates a relative bearing of 45 degrees the aircraft has intercepted the inbound course. Turn right until the Magnetic Compass indicates a heading of 058 degrees (with no wind) and track inbound, using the Direction Indicator to determine wind drift, while descending to the final approach altitude. When the NDB is reached (Direction pointer swings right and left) maintain magnetic compass heading to track 058 degrees (final approach course) and descend to the minimum approach altitude to the airport.

Jeppesen Approach Chart OCT 20-64 (16-1)

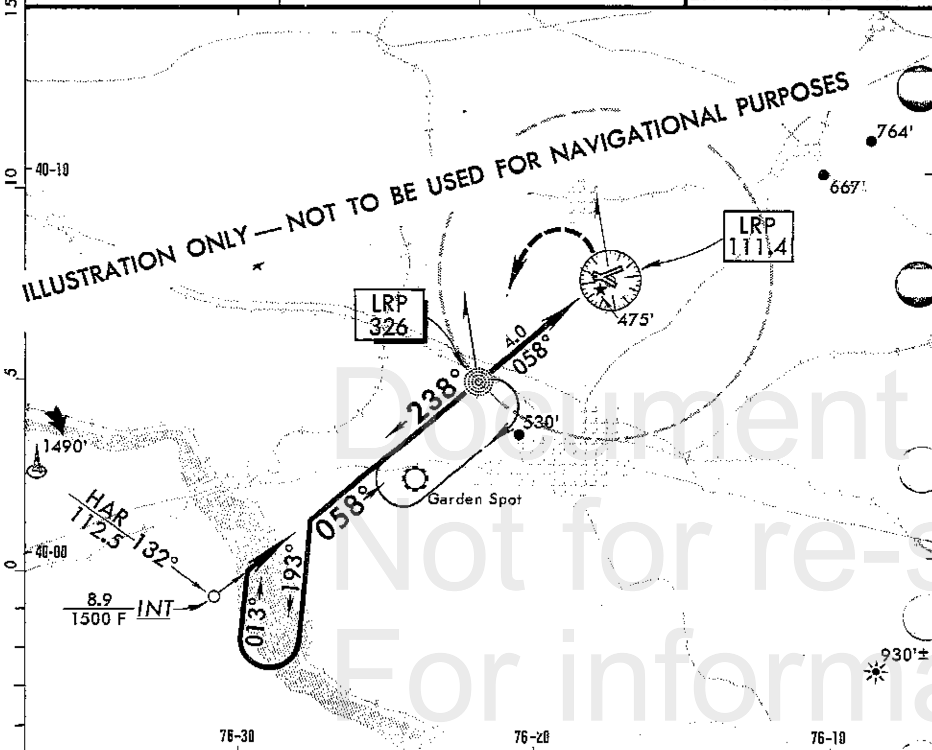
LANCASTER, PA.

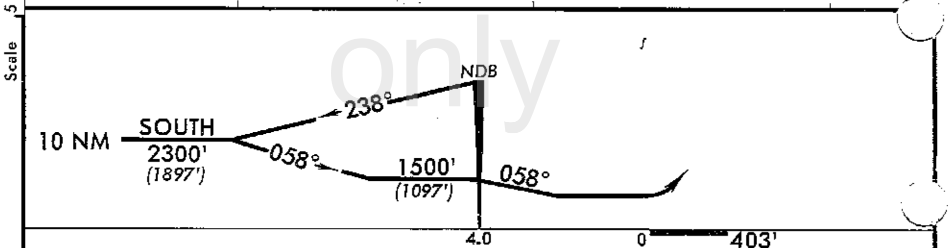
LANCASTER
No. 1 NDB (ADF)
NDB 326 LRP

Apt. Elev. 403'
Var. 08°W
Class MHW

HARRISBURG Approach (R)	Departure (R)	Ground
120.9 360.6	118.8 317.6	

SAFE ALTITUDE
20 NM 4000' 40 NM 4000'





PULL UP: turn LEFT to 2300 *(1897)* feet to LRP NDB and hold.

FAA MINIMA LANDING	SCHEDULED AIR CARRIER & PRIVATE OPERATORS STRAIGHT-IN RWY 8	ALL OPERATORS CIRCLING	NON-SCHEDULED A.C. ST-IN RWY 8
PROP 1 & 2 Eng to 65 Kt	400-1§	500-1	400-1
PROP 1 & 2 Eng over 65 Kt		500-1	500-1
PROP 3 & 4 Eng JET 1, 2 & 3 Eng		¶ 500-1½	
JET 4 Eng	400-1	600-2	500-2

¶ 600-2 Jet 3 Eng.

Ground speed-knots	60	80	100	120	140	160	180	200
NDB to Pull-up 4.0	4:00	3:00	2:24	2:00	1:43	1:30	1:20	1:12

CEILING/ALTITUDE CONVERSION				
QFE	400	500	600	800
QNH	803	903	1003	1203

CHANGES: Procedure turn & pull up altitudes.

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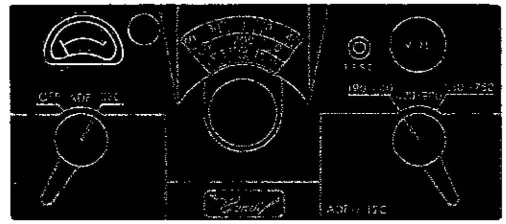
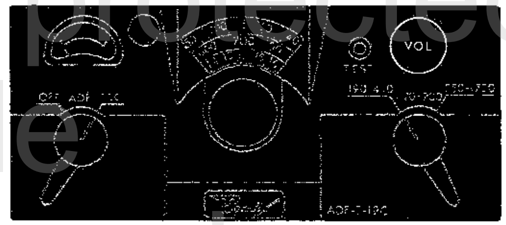
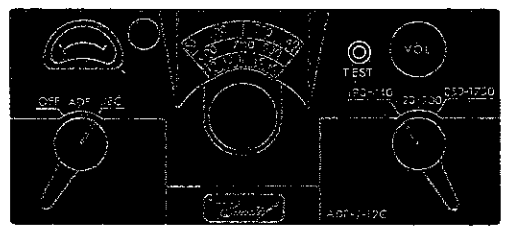


TUNING METER Indicates the level of the received signal. A peak meter reading indicates a properly tuned station.



VOLUME CONTROL Controls the level of sound to the headphones or loudspeaker.



TEST BUTTON Checks equipment operation. In ADF operation, when the button is depressed, the direction indicator pointer moves from the bearing of the selected station. When the button is released, the pointer returns promptly to the bearing of the selected station. A sluggish return or no return indicates a malfunctioning system.

DIRECTION INDICATOR Indicates the bearing of a station in degrees of azimuth relative to the fore-and-aft line of the aircraft.

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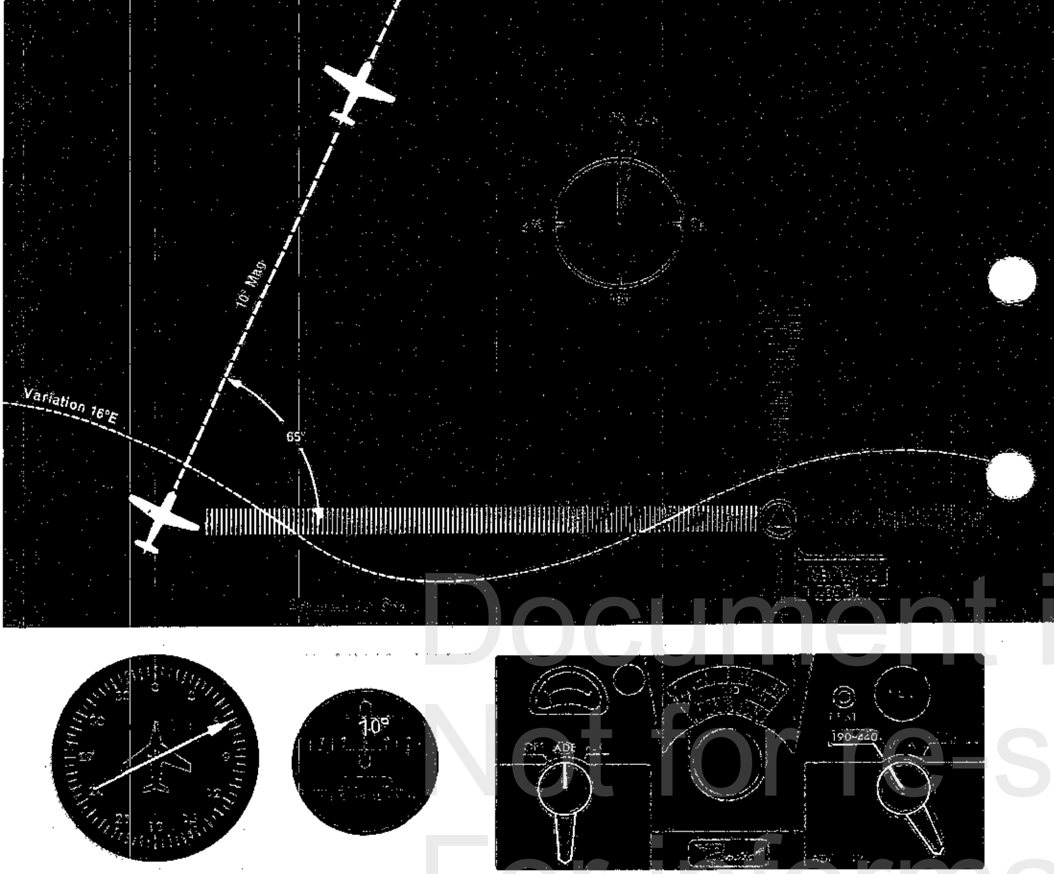

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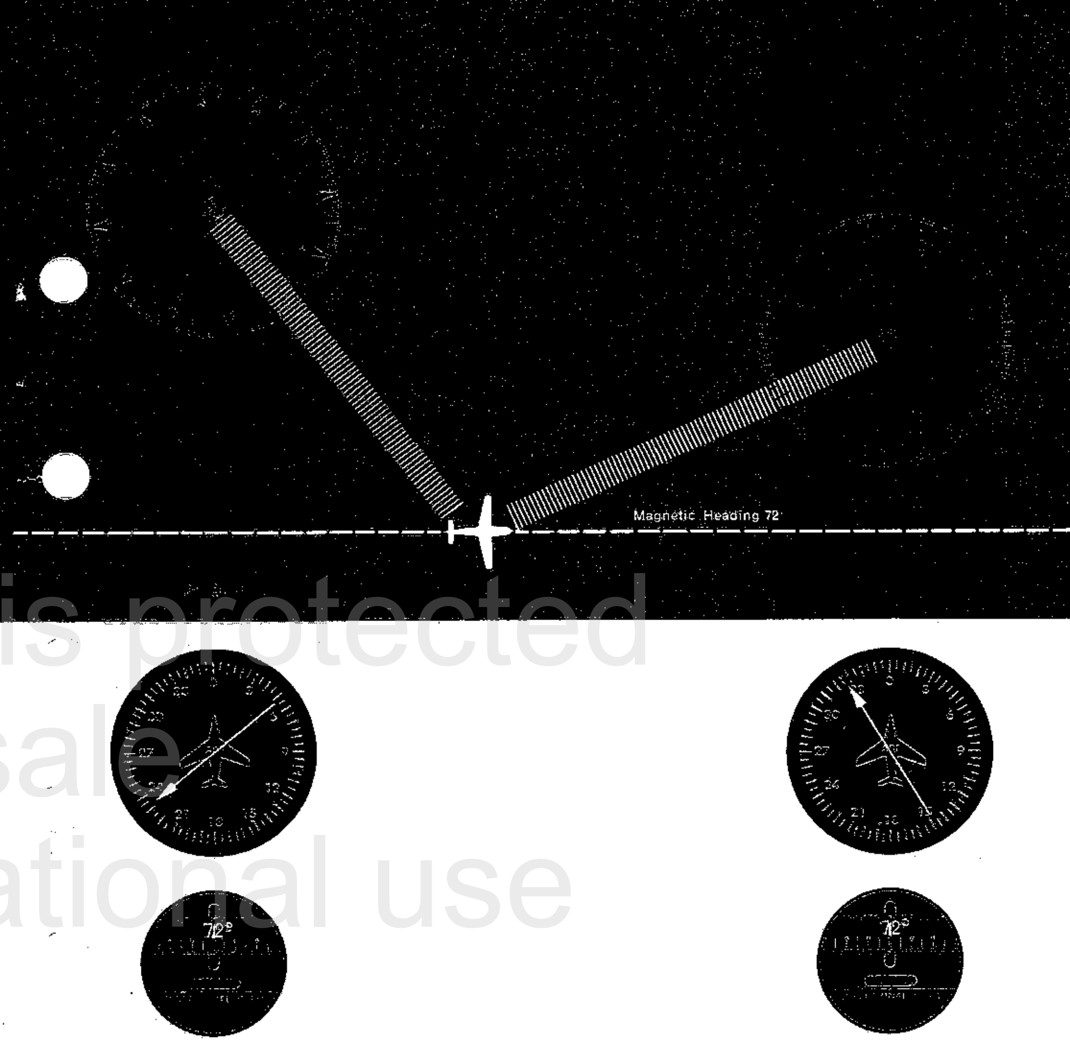
PRINCIPLES OF ADF NAVIGATION The ADF-T-12C provides a visual indication of the relative bearing of a selected transmitting station from the fore-and-aft line of the aircraft. Relative bearings are used in ADF homing procedures and are read directly from the Direction Indicator.

Relative bearings *from the aircraft to the station* must be converted into true bearings *from the station to the aircraft* in order to plot the position of the aircraft on an aeronautical chart. The conversion is accomplished by adding the relative bearing to the aircraft's magnetic heading, correcting for local magnetic variation as indicated on the chart, and then computing the reciprocal of the result.

When using DF charts the position of the aircraft is plotted by converting the *relative bearing* from the aircraft to the station into the *magnetic bearing* from the station to the aircraft. The conversion is accomplished by adding the relative bearing to the aircraft's magnetic heading, and plotting the reciprocal of this result from the station to the aircraft. This procedure is simpler than the previous one due to the fact that on DF charts, low-frequency DF stations are encircled by a compass rose that is oriented to magnetic north. Both procedures are demonstrated in the accompanying illustrations.

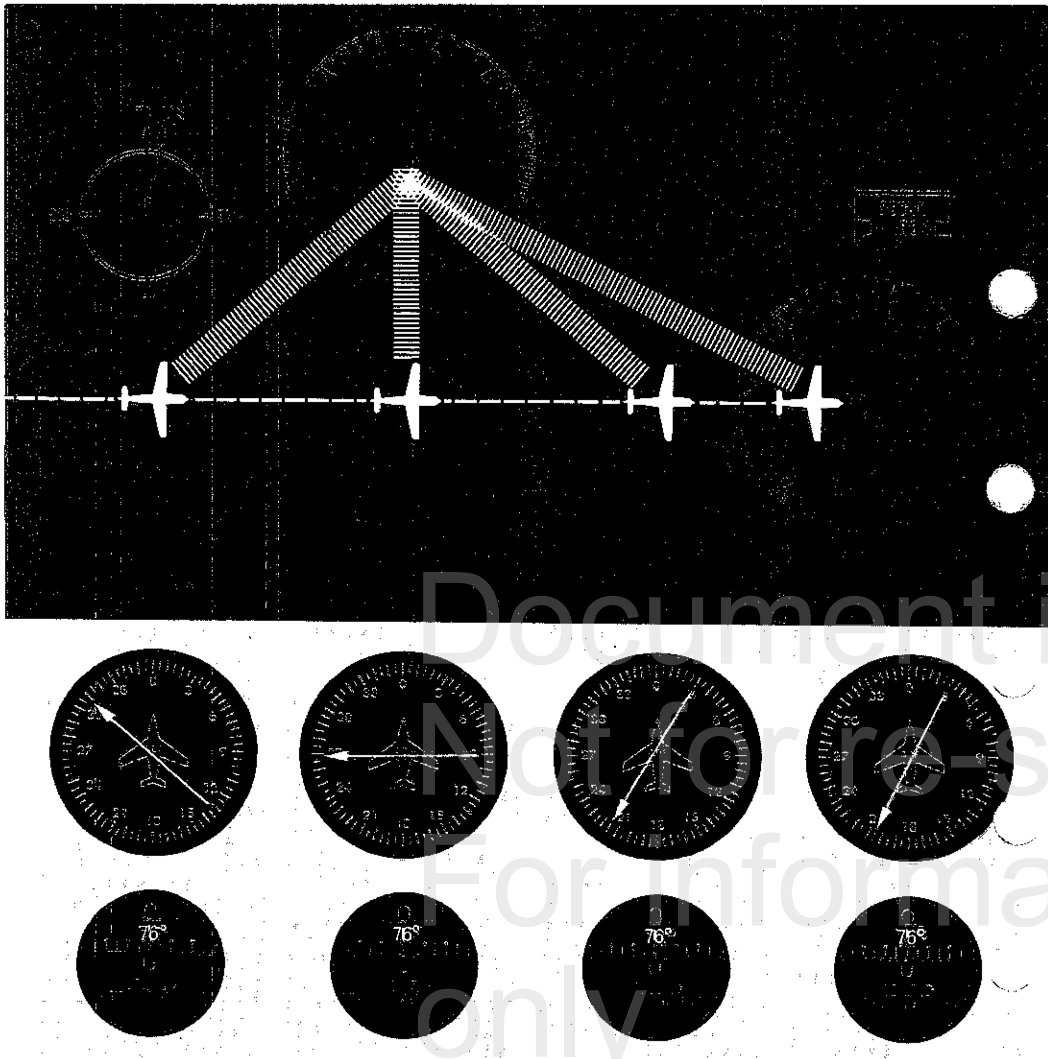
In the first illustration (using an aeronautical chart) the relative bearing from the aircraft to the station is 65 degrees, while the aircraft's magnetic heading is 10 degrees. The local magnetic variation as read from the chart is 16 degrees East. The true bearing from the

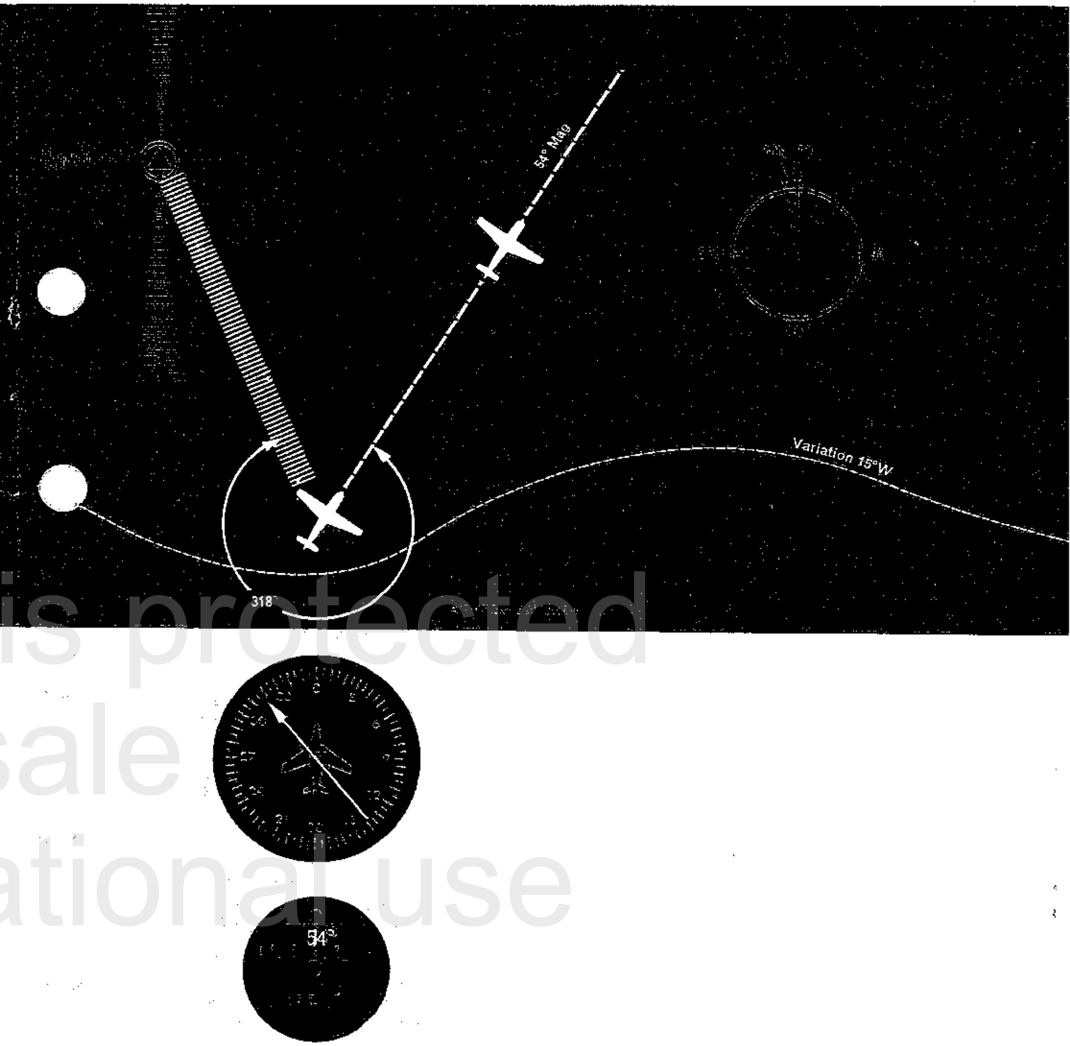


bearing line through the station toward the aircraft. Repeat this procedure with the second station. The position of the aircraft, at the time of the fix, is approximately at the intersection of the two bearing lines.

In the illustration the relative bearing of the first station from the aircraft is 232 degrees, while the aircraft is flying a magnetic heading of 72 degrees. The magnetic bearing of the station from the aircraft is therefore, 304 degrees. The reciprocal magnetic bearing is obtained by subtracting 180 from this figure, which produces a result of 124 degrees. The bearing line is plotted from the station center, through the 124 degree radial toward the aircraft. The relative bearing of the second station from the aircraft is 326 degrees. Computing the reciprocal magnetic bearing, as in the former case, produces a result of 218 degrees. This bearing line is plotted from the center of the second station through the 218 degree radial toward the aircraft. The intersection of the two reciprocal magnetic bearing lines indicates the position of the aircraft at the time of the fix.

The same procedure can be utilized with an aeronautical chart but in this case the relative bearings must be converted to reciprocal true bearings as detailed on Page 6.





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RUNNING FIXES When homing on a station it is a simple matter to keep a running fix by using a second, off-course, station.

To take a running fix, tune off the destination station to the off-course station and record the relative bearing. Convert the relative bearing of the second station to a reciprocal true bearing and draw the bearing line on the chart until it intercepts the course line. The point of interception is the position of the aircraft at the time the second bearing was taken.

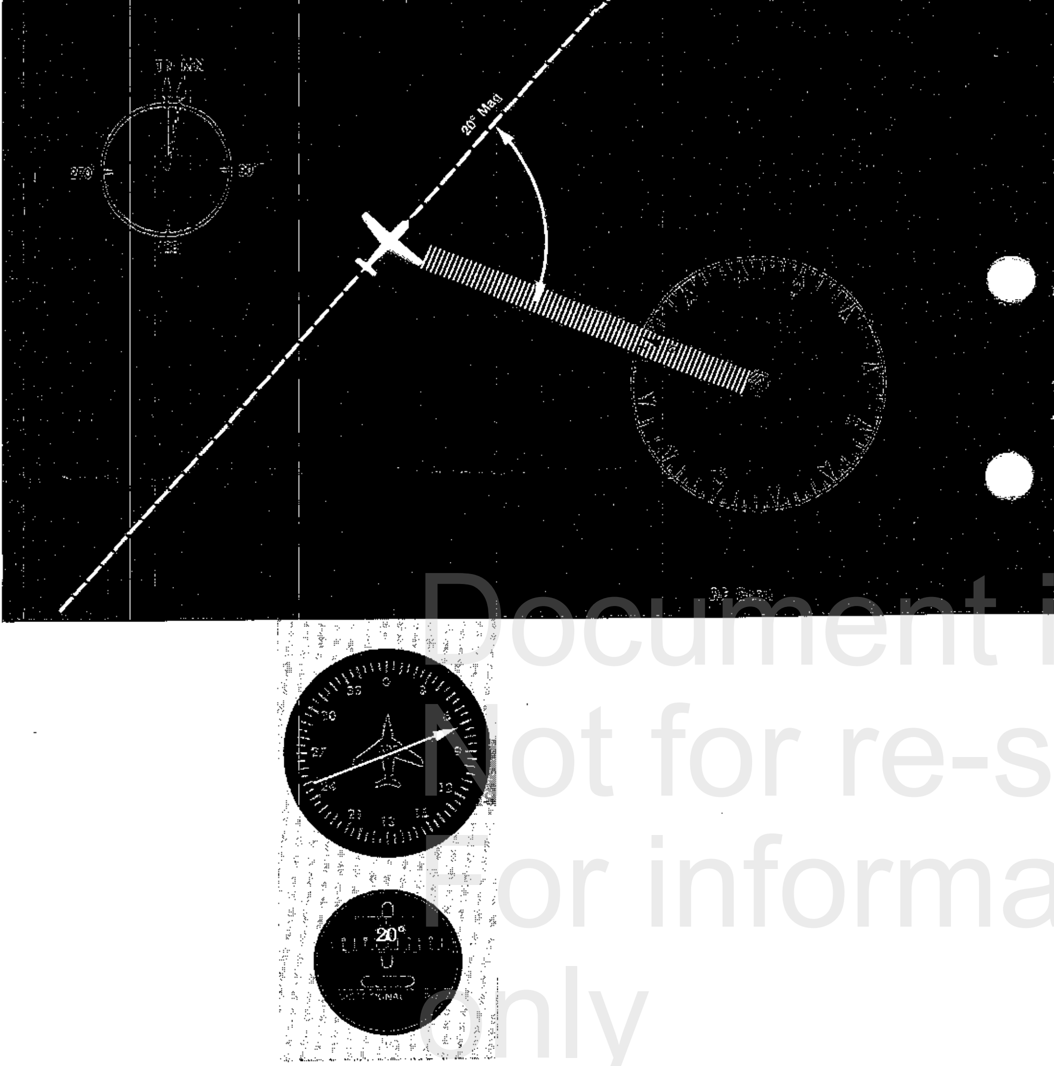
As you continue to the destination station take period relative bearings on the second station, convert them to reciprocal true bearings and plot them on the chart. By recording the time between two consecutive bearings and the distance travelled in that time, the ground speed of the aircraft can accurately be determined. The ETA (estimated time of arrival) can be determined by dividing the distance from the last fix to the station by the ground speed.

ROUGH FIX When a DF chart is available a rapid position fix can be obtained with two ADF stations as follows. Tune in, identify, and take a relative bearing on the first station. Convert this bearing to a reciprocal magnetic bearing (see Page 8) and draw the reciprocal

aircraft to the station is, therefore, $65 + 10 + 16 = 91$ degrees. The true bearing from the station to the aircraft is the reciprocal of this figure, and is obtained by adding 180 (if the bearing is less than 180), or subtracting 180 (if the bearing is greater than 180). In this example the true bearing of the aircraft from the station is $91 + 180 = 271$ degrees. The intersection of two or more bearings plotted in this manner indicates the position of the aircraft.

When computing a reciprocal true bearing, some modifying steps may be required, depending on the geographic location of the aircraft. These steps are as follows:

1. When adding Magnetic Heading to Relative Bearing, subtract 360 if the sum is greater than 360.
2. When correcting for local magnetic variation, ADD EAST variation; SUBTRACT WEST variation.
3. When the addition of East variation results in a total greater than 360, subtract 360 from the sum.
4. When the subtraction of West variation results in a negative figure, subtract this figure from 360.



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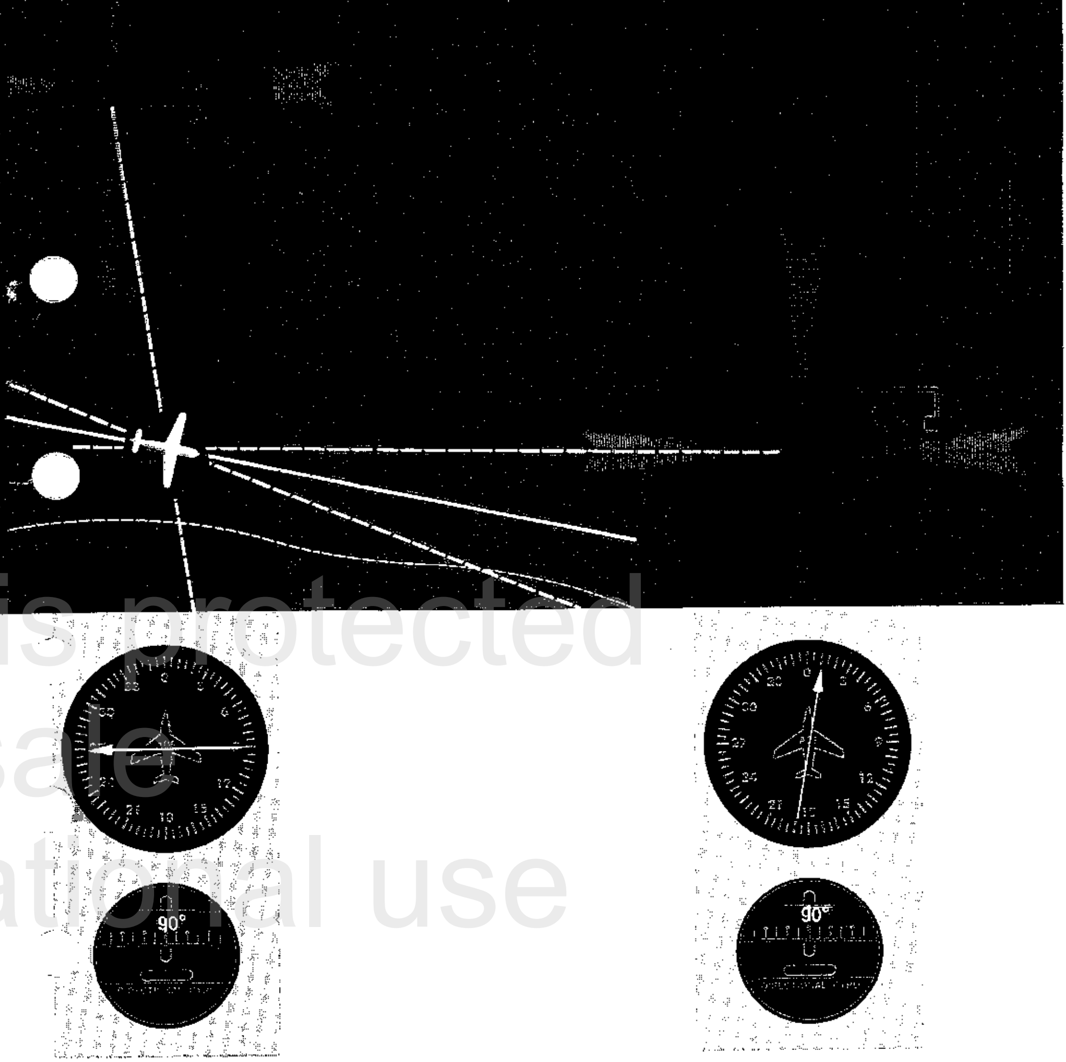
The second illustration demonstrates the computation of a reciprocal true bearing that utilizes the steps listed above. In this case the relative bearing of the station from the aircraft is 318 degrees, while the aircraft's magnetic heading is 54 degrees. The sum of these figures is 372. Subtracting 360, as indicated in Step 1 above, leaves a remainder of 12. The chart indicates that the local magnetic variation is 15W. Subtracting 15 from 12, as indicated in Step 2, leaves – 3. According to Step 4, a minus figure must be subtracted from 360, to produce the true bearing, which in this case is 360 – 3 = 357. As this figure is greater than 180, the reciprocal is obtained by subtracting 180 from it. The reciprocal true bearing is therefore 357 – 180 = 177 degrees.

The third illustration demonstrates the simplified procedure applicable when DF charts are available. Here, the relative bearing from the aircraft to the station is 70 degrees, while the aircraft's magnetic heading is 20 degrees. The magnetic bearing from the aircraft to the station is, therefore, 70 + 20 = 90 degrees. The magnetic bearing from the station to the aircraft is the reciprocal of this figure, i.e. 90 + 180 = 270 degrees. This bearing is plotted by drawing a line from the station center through the 270 degree radial on the station compass rose.



of the Direction Indicator for each station. After recording the last bearing, note the time. Convert each of the relative bearings to a reciprocal true bearing (refer to Page 6).

Use a plastic protractor (or plotter) to plot the bearings on the chart. Set protractor center at station marker. Line up protractor base parallel to line of longitude or line of latitude, whichever is most convenient. Draw reciprocal true bearing lines from each station until they intersect. The aircraft lies within the triangle. If a three bearing fix produces too large a triangle, re-take the bearings using, if possible, one different station.

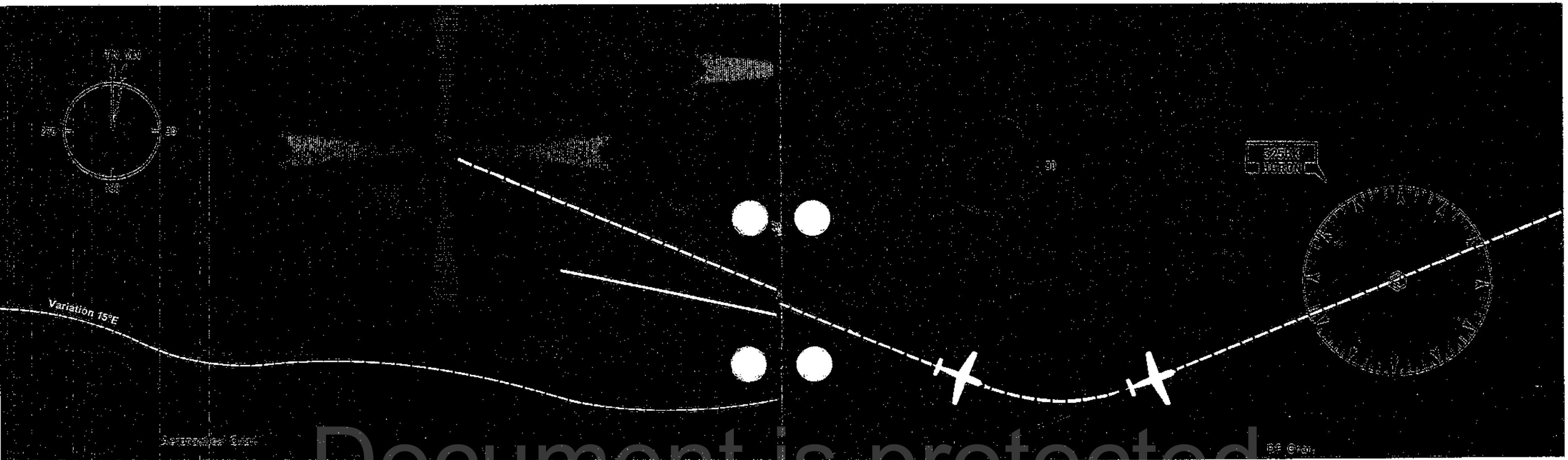
In a three-bearing fix, an over-large triangle may result from one of the following causes.

Bearings taken in too slow succession.

Stations improperly tuned in.

Constant magnetic heading not maintained while bearings were taken.

Unsatisfactory station reception.



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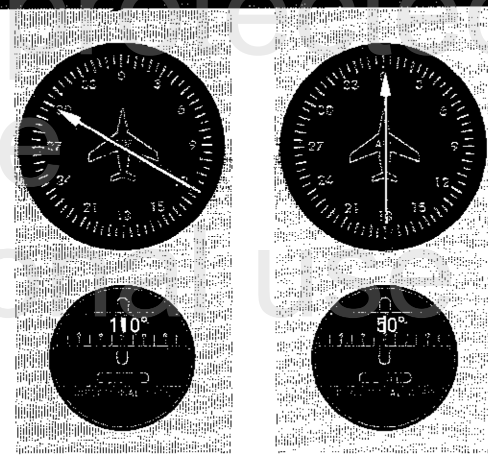
POSITION FIXING BY TRIANGULATION To plot an accurate position fix on a radio navigation chart use stations that are widely separated, but no further than 100 miles away from the estimated position of the aircraft. At least two stations must be used to obtain a fix. If a third station is used, results will be more accurate.

Fly a constant magnetic heading while taking bearings. The same heading must be held while taking all bearings for a particular fix. Wind drift does not matter so long as the magnetic compass shows the same reading while bearings are being taken.

Tune in the stations carefully, noting the exact position on the tuning dial where each station gives maximum volume or a peak reading on the tuning meter. Peaking the tuning meter is the more accurate method of tuning, and for accurate results, each station must be tuned in exactly on the center of its signal.

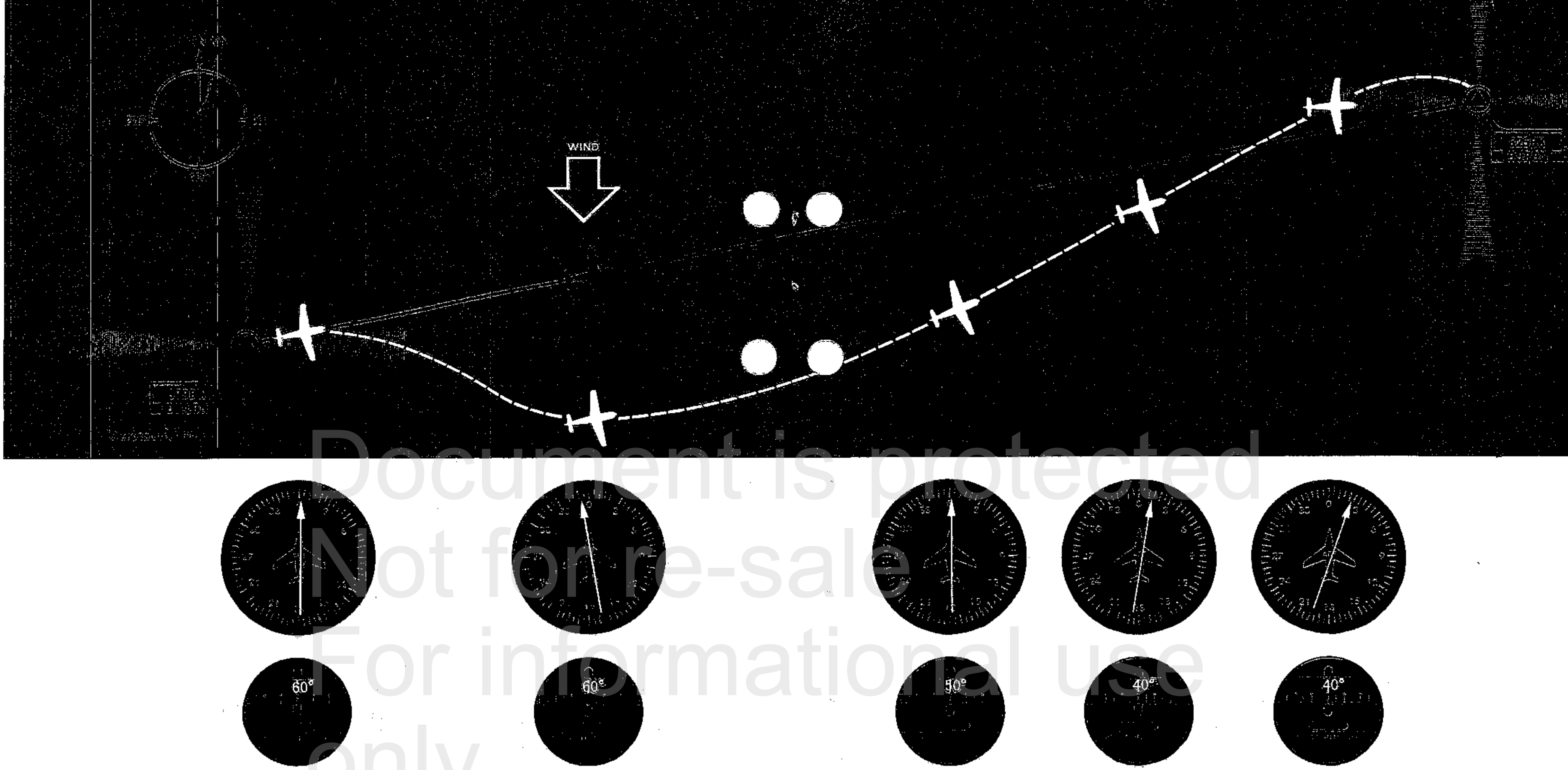
As rapidly as possible, tune in the stations previously identified and record the bearing



ADF OPERATION: CONVENTIONAL HOMING To home, tune in and identify a station that is at or near the intended destination. Use the REC position of the function switch. For accurate results, exact tuning is absolutely necessary. Maximum signal strength, as observed on the tuning meter, indicates exact tuning of the station. After the station is identified by its call letters turn the function switch to the ADF position. The indicator pointer will swing to show the relative bearing of the transmitting station. Turn the aircraft until the pointer indicates a relative bearing of zero (0) degrees. Hold the zero reading by flying to the needle.

When the station is reached, the needle will vary on either side of 0 degrees and then swing abruptly to a reading of 180 degrees to indicate that the station has been passed.

WARNING: *Do not "home away" from a station (i.e., fly an ADF course of 180) using this homing method. When one station is passed, tune in the next and home toward it. Never trust a signal that has not been accurately identified. Never trust a signal with a beat note or "warble" since this sound generally indicates that interference from a distant station on the same frequency is present.*



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TRACKING, OR HOMING WITH A CROSSWIND Flying a relative bearing of zero degrees will in all cases result in the aircraft arriving over the station. In the presence of an appreciable crosswind, however, the route will be circuitous, and it may be desirable to fly a heading into the wind to compensate for drift. One way to accomplish wind drift compensation, or tracking, is to fly a constant magnetic heading while observing the direction and rate of change of the relative bearing indicator. When the relative bearing error has been established in this manner the aircraft is steered into the wind until the change in magnetic heading is equal to twice the relative bearing error. The pilot maintains the new magnetic heading to return to the course line. As the correct course line is approached the relative bearing increases. When the relative bearing error is equal to the change in magnetic heading, the aircraft is crossing the correct course line. The pilot holds the correct course line by steering to maintain the two errors equal.

This procedure is demonstrated in the accompanying illustration. Initially the pilot steers the aircraft until the Direction Indicator indicates a relative bearing of 0 degrees, while observing that the compass indicates a magnetic heading of 60 degrees. The pilot maintains this magnetic heading (60) and observes the direction indicator pointer. As the crosswind causes the aircraft to drift from the correct course, the direction indicator pointer changes from the relative bearing of 0 degrees to the relative bearing of 350 degrees over a period of several minutes, which indicates that the wind is from the left and that the aircraft is drifting to the right of the correct course. The pilot now steers the aircraft to the left (into the wind) until the compass indicates a magnetic heading of 40 degrees, i.e. the change in magnetic heading is double the change in relative bearing, and maintains this magnetic heading to return to the correct course line. As the correct line is approached on the new magnetic heading, the relative bearing error increases from the initial 10 degrees. When the relative bearing error equals the magnetic heading error (i.e. 20 degrees) the aircraft is crossing the correct course line. By steering to maintain the two errors equal, the pilot will hold the correct course line. In practice, several brackets of the correct course line may be required to determine the correct crab angle.