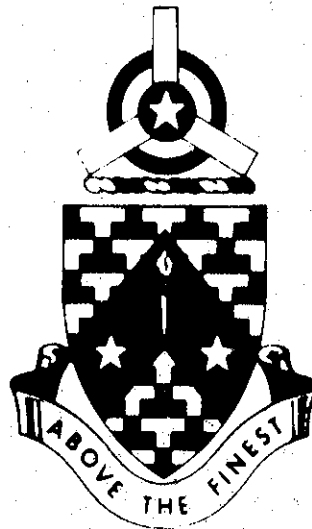(4,5,6)

PROGRAMED TEXT

MAP READING
Part V
DIRECTIONS (AZIMUTHS, PLOTTER)

WD-40

AUGUST 1968

UNITED STATES ARMY

PRIMARY HELICOPTER SCHOOL

FORT WOLTERS, TEXAS

PROGRAMED TEXT

PROGRAM TEXT

FILE NO:	**PROGRAM TITLE**
WD-40	Map Reading
	Part V
	Directions
	(Azimuths, Plotter)

POI SCOPE: Declination diagram, azimuths and back azimuths, plotting grid azimuths using aeronautical plotter.

INSTRUCTOR REFERENCES:

FM 21-26; TM 1-225

PREPARED BY:	**DATE:**
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APPROVED BY:	**DATE:**
MARTIN HEUER, LTC	August 1968
Dir, OCD	

TABLE OF CONTENTS

PREFACE

Program V, Directions, covers a method used to determine a direction by using any one of three base lines: grid, magnetic, or true north as a reference. It also teaches you how to plot an azimuth (direction) utilizing the aeronautical plotter.

The following materials are essential in answering the frames in this text:

Map of LEAVENWORTH, KANSAS, 1:50,000

Map of LIPAN, TEXAS, 1:50,000

Map of WEATHERFORD, TEXAS, 1:50,000

Aeronautical Plotter

Coordinate Scale

PERFORMANCE OBJECTIVES

Upon completion of Part V you will be able to:

A. Determine the value of grid and/or magnetic declination for any given map.

B. Select the map symbols for true, grid, and magnetic north.

C. Determine the G-M angle for any given map.

D. Compute the back azimuth of any given azimuth.

E. Plot grid azimuths and back azimuths on a map utilizing the aeronautical plotter.

F. Determine the grid azimuth between two given points on a map.
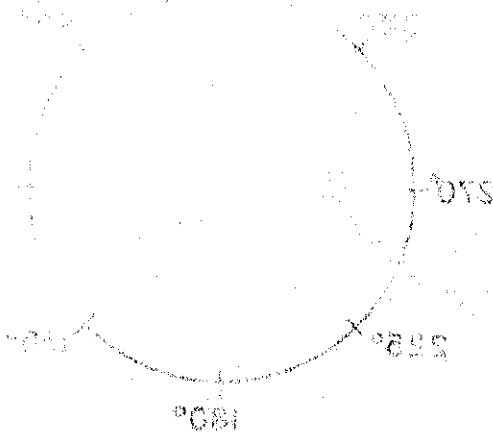
DIRECTIONS (AZIMUTHS, PLOTTER)


Set 1.   NORTH LINES

FRAME 1

Directions may be expressed in everyday life as: "on the right side of the road", "on the left bank of the river", etc. In these examples, the _____ and the _____ have been used as references from which to more accurately express direction.

(a.   true north; b.   clockwise)   (12)

FRAME 13

The figure below shows a circle divided into degrees. Note that like an azimuth, degrees are numbered in a (clockwise) (counterclockwise) direction.
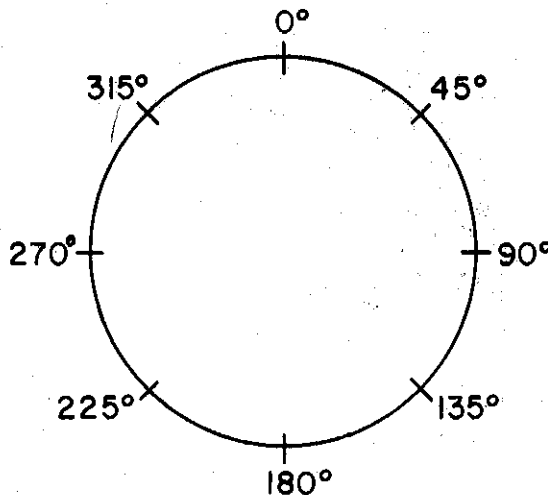
(a. 205°; b. 24°; c. 136°; d. 267°) (24)

FRAME 25   INFORMATION FRAME

   Azimuths and back azimuths can be plotted accurately on a map by referring
to a declination diagram. (See Leavenworth map.) Declination is the angular
difference between true north, and either (1) magnetic north or (2) grid
north. The declination diagram graphically shows the interrelationship of
magnetic, grid, and true norths. In using a military map, you will be inter-
ested primarily in the angular difference between magnetic north and grid
north - the G-M angle.

$$\checkmark - \left(\frac{\bigstar + (G \cdot N)}{2}\right) \quad or \quad \left[\frac{-(\bigstar \pm \prime)}{2}\right]$$

FRAME 37

   (Refer to diagram on previous frame.)

   Your plotter has an index hole and three scales (outer, middle, special)
on the semi-circular portion. From your knowledge of angular units which
divide a circle, these three scales are divided into ___degrees___.

(road, river)   (1)

In military map reading, directions are referenced to a north line instead of to roads, rivers, etc. The _*north*_ line establishes a starting point from which directions are expressed.

(clockwise)   (13)

Consider that you are standing in the center of the circle shown below. When you face toward any north (true, grid, or magnetic) you are facing 0°. When facing to the west, you are facing _*270°*_ degrees.
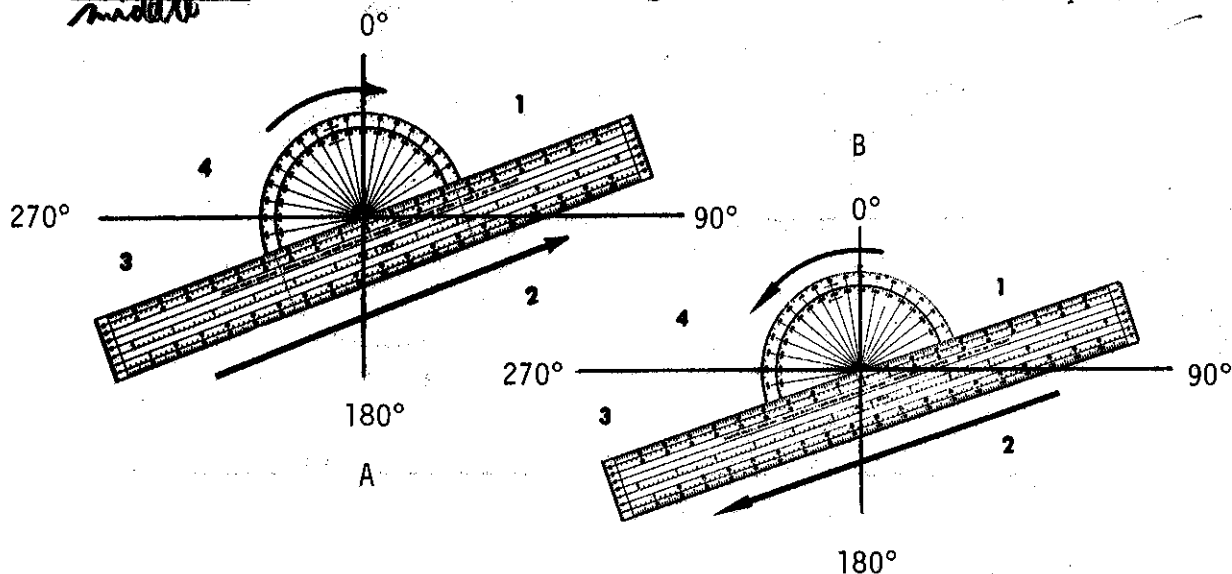
FRAME 26
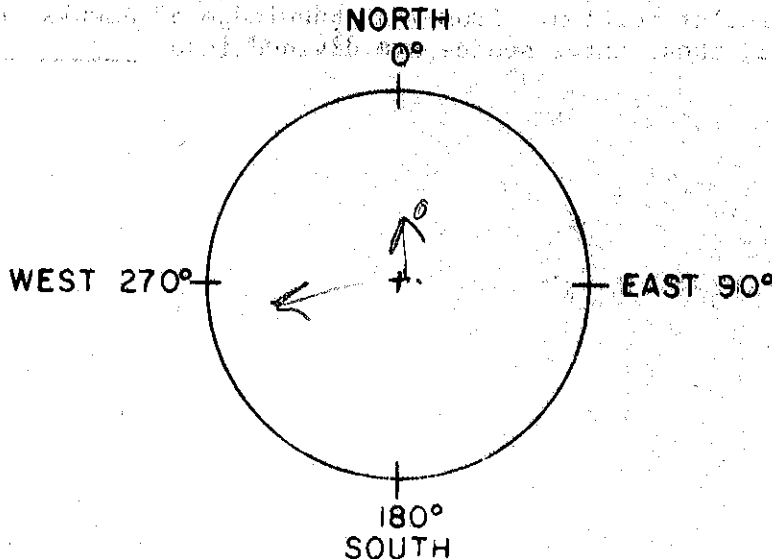
A dashed-line arc is drawn on the declination diagram, as shown, to connect the __*grid*__ north and __*magnetic*__ north lines.

FRAME 38

Diagram A, below, shows you that the outer scale (0° to 180°) is for reading directions in the first and second chart quadrants. Diagram B shows that the __*inner*__ scale is used for reading in the third and fourth quadrants.
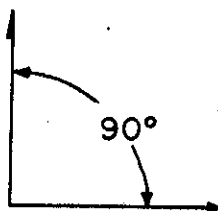
FRAME 3

Three north lines, from which directions are measured in map reading, are shown in Panel 4-1 (page 26). Study this panel. Complete the chart below.

SYMBOL		NORTH LINE
❙	a.	*magnetic north*
★	b.	*true north*
"GN" or "Y"	c.	*grid north*

(270 degrees)   (14)

FRAME 15

In the spaces below, write the azimuths indicated in sketches A and B.

GN

90°

270°

A

B

a. *magnetic azimuth of* 90°   b. *Grid azimuth of* 270°
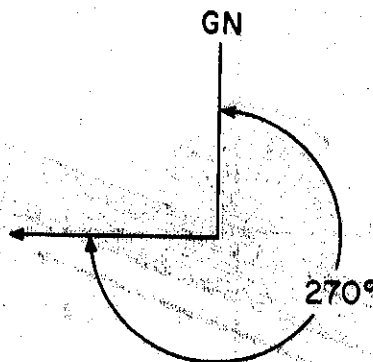
6

FRAME 27

The angle between the grid north and magnetic north lines is called a grid-magnetic (G-M) angle. The grid-magnetic angle is <u>always</u> measured from grid north to magnetic north (G to M) and is expressed as a value and a direction. The direction will be east if magnetic north is to the right of grid north and west if magnetic north is to the left of grid north. The grid-magnetic angle shown is __9 1/2°__ degrees or __169__ mils, __east__ (direction).

GN

1965 G-M ANGLE
9 1/2° (169 mils)
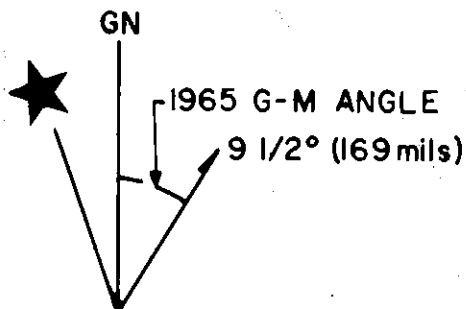
(middle scale)   (38)

FRAME 39

The steps for plotting a 60° azimuth from a known location (point A) are listed below:

(1) Place pencil tip on point A. (2) Place straight edge of plotter against pencil tip. (3) Center index hole over a vertical grid line. (4) Rotate plotter until desired azimuth (60°) on the outer scale is over the same vertical grid line as index hole. (5) Draw line from point A along edge of plotter.

(4)

(5)

(3)

(2)

A
(1)
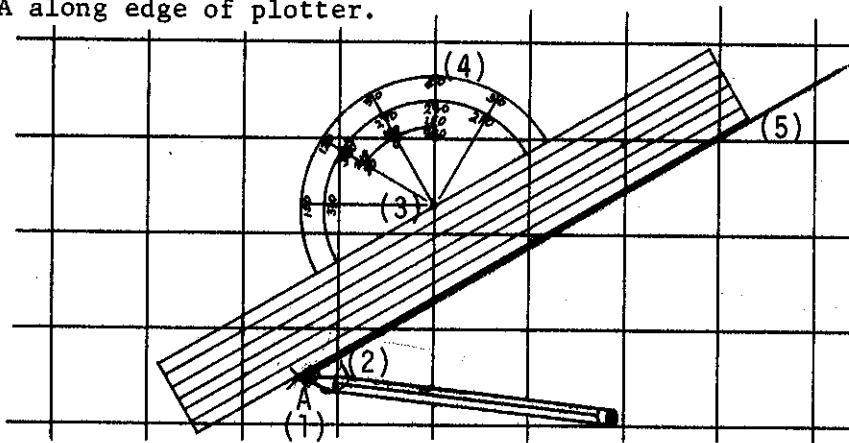
(a. Magnetic north; b. True north; c. Grid north) (3)
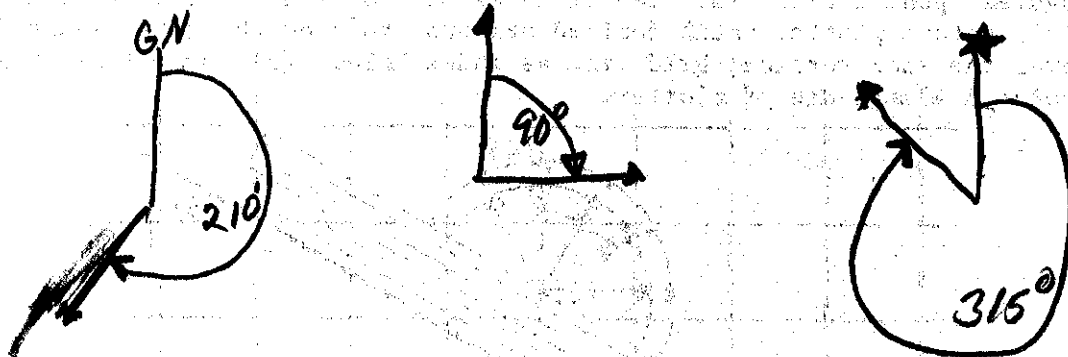
FRAME 4

A direction measured from a true north line may be illustrated as shown below. Under the diagrams below write the name of the north line from which the indicated direction is measured.

true north

Grid north, magnetic north
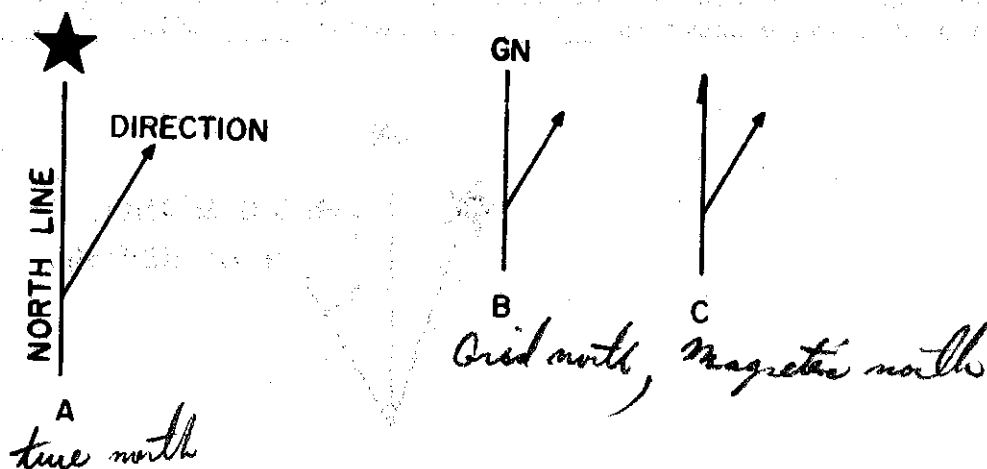
(a. magnetic azimuth of 90°; b. grid azimuth of 270°) (15)

FRAME 16

Sketch the listed directions in the spaces provided below. Label the angle and show the direction from the north line from which the angle was measured.
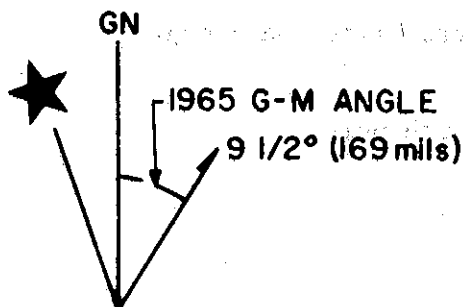

a. Grid azimuth — 210° b. Magnetic azimuth — 90° c. True azimuth — 315°

(9 1/2 degrees, 169 mils, east) (27)

FRAME 28

The date the G-M angle was prepared is also noted on the diagram. The
G-M angle shown was prepared in *1965* .

GN

1965 G-M ANGLE
9 1/2° (169 mils)

FRAME 40

Turn to Panel 4-3 (page 28). Using your plotter, plot an azimuth of 45°
from point D. What point does your azimuth cross? (If necessary, refer back
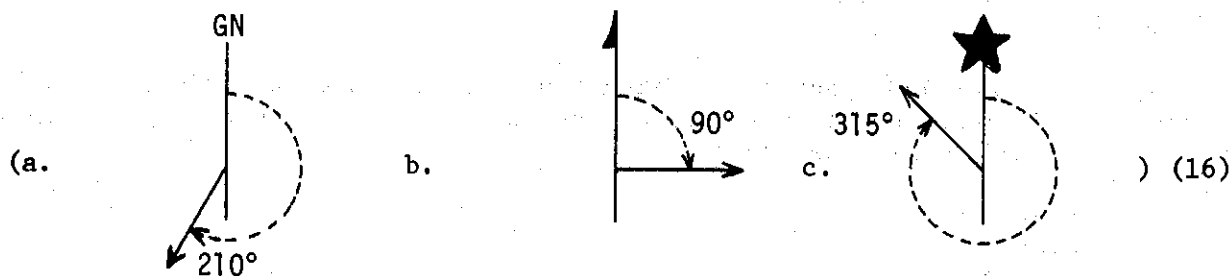to Frame 39 and review the steps).

    a.   Point A
    b.   Point B
    c.   Point C

(a. true north; b. grid north; c. magnetic north) (4)

FRAME 5

Draw the appropriate symbols of the north lines which are described below.

LINE DERIVED FROM: SYMBOL

a. Compass direction of magnetic north.   a. _ϟ_

b. Vertical grid lines on a map.   b. _GN_ ∿ Y

c. Earth's north pole.   c. _★_

(a. ... GN ... 210°   b. ... 90°   c. ... 315° ... ★) (16)

Set 3. BACK AZIMUTH MEASUREMENT

FRAME 17   INFORMATION FRAME

In map reading, it is often required that a back azimuth be determined. A back azimuth is the reverse direction of an azimuth. It is comparable to doing an "about face." It is the opposite direction of the azimuth. Back azimuths are used to determine the position of the observer or unit when the location is not known. This will be discussed in later frames. Study Panel 4-2 (page 27), then proceed to the next frame.

FRAME 29

The arc connecting the grid north and magnetic north lines is called a
_G_ _M_ angle.

grid *magnetic*

(b. Point B) (If your answer was incorrect, try again. NOTE: The degrees
printed on the scales increase in a counterclockwise direction.) (40)

FRAME 41

Refer again to Panel 4-3. Place your plotter in the same position as
before (45° azimuth from D to B). What would the azimuth be from B to D?
(Read from the middle scale.) _225°_

(a. ___↑___ ; b. ___GN⊥___ ; c. ___★⊥___) (5)

FRAME 6.

In the space provided below, draw the symbols of the three north lines, write the names of the lines, and state how the lines are derived.

SYMBOL	NAME	HOW DERIVED
a. _↑_	_magnetic NORTH_	_compass_
b. _★_	_true north_	_north pole_
c. _GN or Y_	_grid north_	_map reference_

FRAME 18

Refer to Panel 4-2 (page 27). This panel shows that back azimuth angles, like azimuth angles are measured in a __clockwise__ direction from the base line.

(grid-magnetic) (NOTE: This angle is referred to as the G-M angle.) (29)

FRAME 30

Refer to the Leavenworth map and locate the declination diagram in the bottom margin. The G-M angle on the Leavenworth map is _9 ½_ degrees, (east) (west), and was prepared in _1960_.

_____

(225°) (This is the back azimuth of 45°. 45 + 180 = 225.) (41)

FRAME 42

On Panel 4-3, plot a grid azimuth of 140° from Point A. If you extended your azimuth line it would cross

a.   Point H.
b.   Point I.
c.   Point G.

13

(a.   True north   Earth's north pole

b.   Magnetic north   Compass direction of magnetic north

GN

c.   Grid north   Vertical grid lines on map)   (6)

FRAME 7

Any line you draw on the map, parallel to the grid north line, shown on your map, is a grid north line. Similarly, any lines __*parallel*__ to the magnetic north and true north lines shown on your map are magnetic north or true north __*lines*__ . Grid north lines and magnetic north lines are most commonly used in determining direction on military maps.

(clockwise)   (18)

FRAME 19

Panel 4-2 also shows that a back azimuth is determined from an azimuth by either adding or subtracting __180°__ .

(9 1/2° or 9°30', east, 1960)   (30)

FRAME 31

The angle between TRUE north and GRID north is called <u>Grid Declination</u>. Grid Declination is <u>always</u> measured from True north to Grid north and is expressed as a value and a direction.   What is the Grid Declination for the Leavenworth map?

_1_° _11_' (east) (west)

(c.   Point G)   (42)

FRAME 43

Now practice plotting azimuths that are in the third and fourth quadrants. Turn back to Panel 4-3 and plot a grid azimuth of 230° from Point X.   Your azimuth line crosses

a.   Point D.

b.   Point Y.

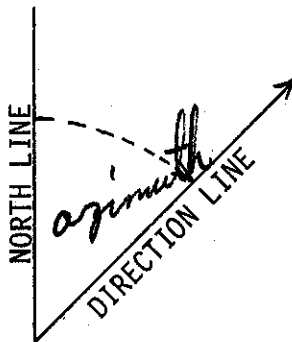c.   Point Z.

Set 2.   AZIMUTH MEASUREMENT

FRAME 8

The most common military method of expressing a direction is by using an azimuth. The figure below shows a north line and a direction. The angle between the north line and the direction line, shown by a dashed line, is an
_____*azimuth*_____.

FRAME 20

When the azimuth angle is 180° or less, to find the back azimuth you

  (a.) add 180°.

  b.   subtract 180°.

FRAME 32

On some maps the Grid Declination (angle between GN and True North) is not shown in the diagram but is printed in the center of the bottom margin just above the Grid Zone Designation Square. Refer to your Weatherford map. What is the grid declination for this map?

_0_ ° _37_ ' (east)̶ (west)

FRAME 44   INFORMATION FRAME

When measuring an azimuth that is nearly north or south (0° or 180°), it may be difficult to use the plotter in the manner you have just learned. The special scale can be used to measure an azimuth that is within 30° either side of north or south. The index and desired azimuth are placed over a HORIZONTAL grid line when using the special scale.
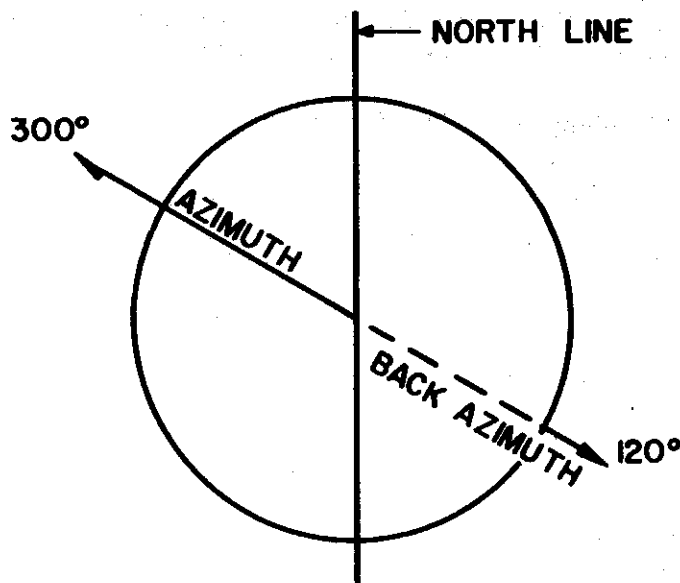
17
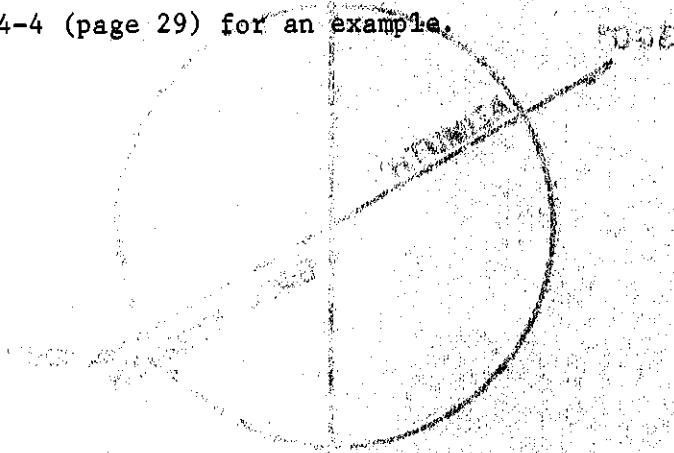
(azimuth) (8)

FRAME 9

    The arrow on the dashed line in Frame 8 shows that the azimuth angle is measured in a (clockwise) (counterclockwise) direction from the north line.

(a. add 180°) (20)

FRAME 21

    Study the figure below. In this case, the back azimuth is determined by (adding) (subtracting) 180°. Back azimuth is simply the opposite direction of the azimuth.

FRAME 33

The angle between TRUE north and MAGNETIC north is called <u>Magnetic</u> <u>Declination</u>. Magnetic Declination is <u>always</u> measured from True north to Magnetic north and is expressed as a value and a direction. What is the Magnetic Declination for the Leavenworth map?

__8__ ° __19__ ', (east) (west)

$$\frac{\begin{matrix} 9 & 3 & 0 \\ & 1 & 1 \end{matrix}}{8 \quad 19'}$$

FRAME 45

On Panel 4-3, determine the grid azimuth from Point M to N using the special scale on your plotter.

a. 346°
b. 354°
c. 165°

19

(clockwise) (9)

FRAME 10

All azimuths are measured in the same manner--they are measured in a
Clockwise direction from the north line.

(subtracting) (21)

FRAME 22

To obtain a back azimuth from an azimuth, (add) (subtract) 180° if the
azimuth is 180° or more.

FRAME 34

What is the magnetic declination for the Weatherford map? *9° 18' east*

$$8\ 41'$$
$$.37$$
$$\overline{878}$$
$$9°18'$$

FRAME 46

On your Leavenworth map, plot a grid azimuth of 340° from the Quinn School (452 639). If you extend your azimuth line from the school it crosses what man made feature in grid square 4466? *Flintlock Church.*

FRAME 11

Figure A shows a "true azimuth angle", so named because the azimuth angle shows a direction as related to a true north line. B shows a *magnetic azimuth angle* and C shows a *grid azimuth angle* .
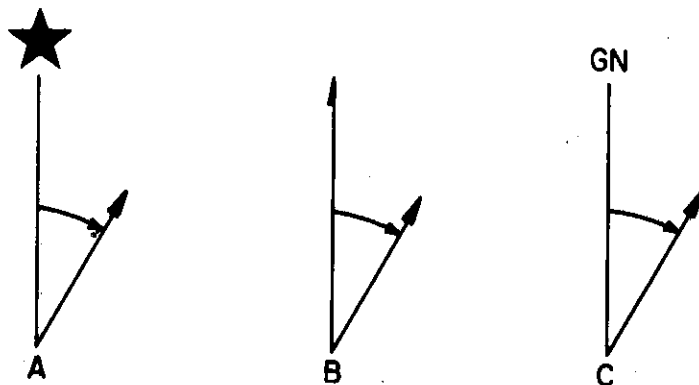
FRAME 23

If the azimuth is less than 180°, you *add* 180° to obtain the back azimuth; if the azimuth is more than 180°, you *subtract* 180° to obtain the back azimuth.

(9°18', east) (34)

FRAME 35

What is the G-M angle on the Weatherford map? _7_° _41_' (east) (west)

(Flintlock Church) (46)

FRAME 47

What is the grid azimuth from the Eldorado School (418 551) to the Lanter School (457 501) on your Leavenworth map?

a. 338°
b. 142°
c. 322°
d. 158°

FRAME 12

Azimuth angles are commonly expressed in degree units of angular measure. A true azimuth of 45 degrees (written 45°) is, therefore, a direction. It tells us that:

a. The north line used as a reference for measuring was a _*true*_ _*north*_ line.

b. The azimuth of 45° was measured in a _*clockwise*_ direction.

(add, subtract)   (23)

FRAME 24

Determine the back azimuths for the directions listed below and write them in the spaces provided.

a. Grid azimuth = 25°; grid back azimuth = _205_°.

b. Magnetic azimuth = 204°; magnetic back azimuth = _24_°.

c. True azimuth = 316°; true back azimuth = _136_°.

d. Grid azimuth = 87°; grid back azimuth = _267_°.

(8°41', east)   (35)

Set 5.   USE OF AERONAUTICAL PLOTTER TO PLOT AZIMUTHS

FRAME 36   INFORMATION FRAME

An aeronautical plotter is an aid to assist you in laying out and measur-
ing azimuths on a map. The scales printed on the rectangular part of the
plotter are not to be used on a tactical map as you have been using in this
program, but are designed for use with aeronautical charts. You will study
these charts during your classes in air navigation. The plotter provided
for your use in this course is pictured below.
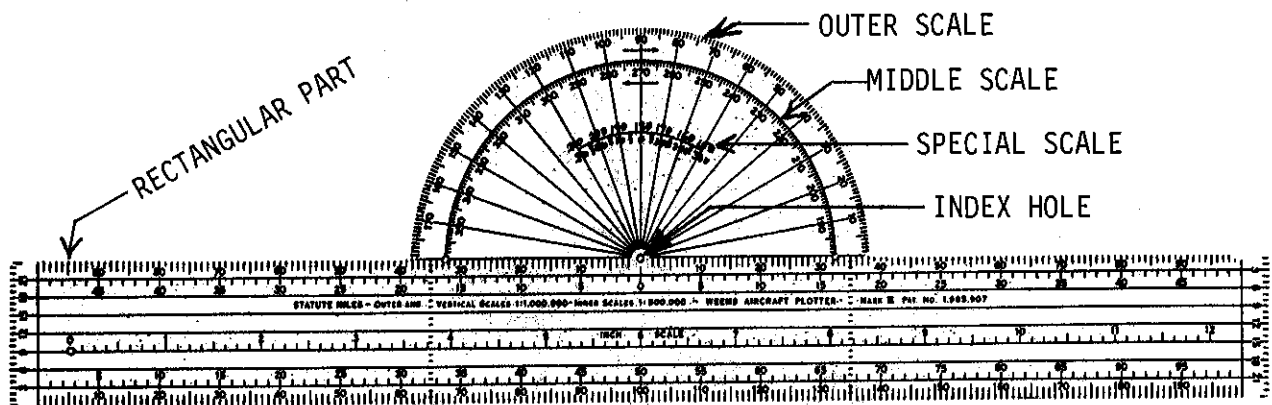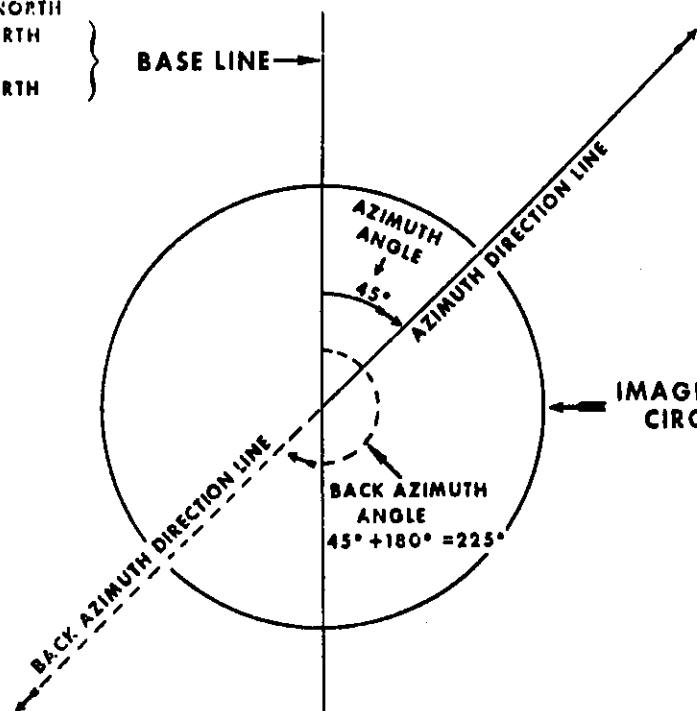

(b. 142°)   (47)

END OF PART V

PANEL 4-1

MAGNETIC NORTH, TRUE NORTH, AND GRID NORTH
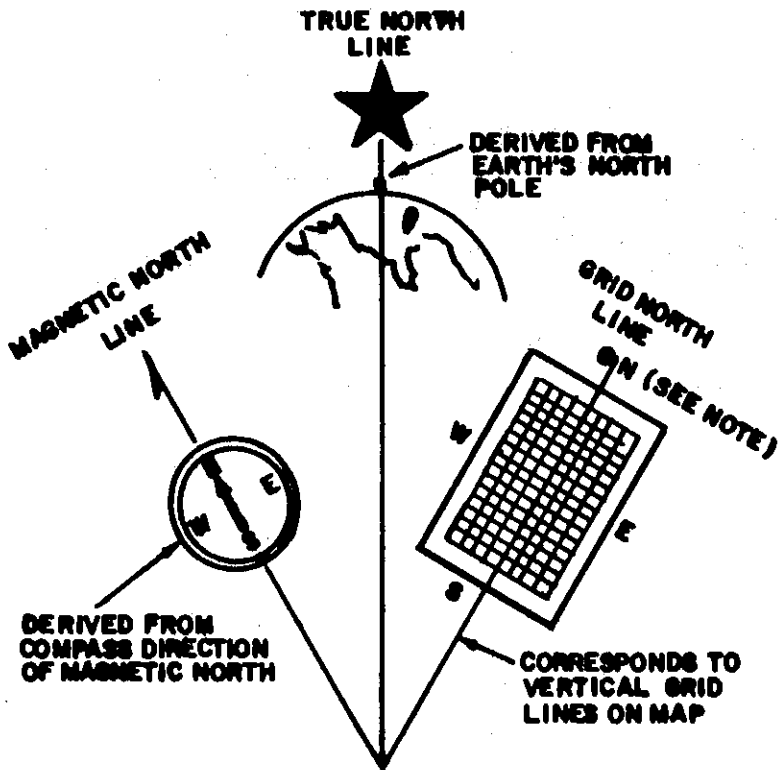
NOTE: THE LETTER "Y" CAN BE USED INSTEAD OF "GN"

MAGNETIC NORTH
TRUE NORTH
OR
GRID NORTH }

BASE LINE →

AZIMUTH ANGLE

45°

AZIMUTH DIRECTION LINE

BACK AZIMUTH DIRECTION LINE

BACK AZIMUTH ANGLE
45° + 180° = 225°

IMAGINARY CIRCLES

BASE LINE →

BACK AZIMUTH ANGLE
205° − 180° = 25°

BACK AZIMUTH DIRECTION LINE
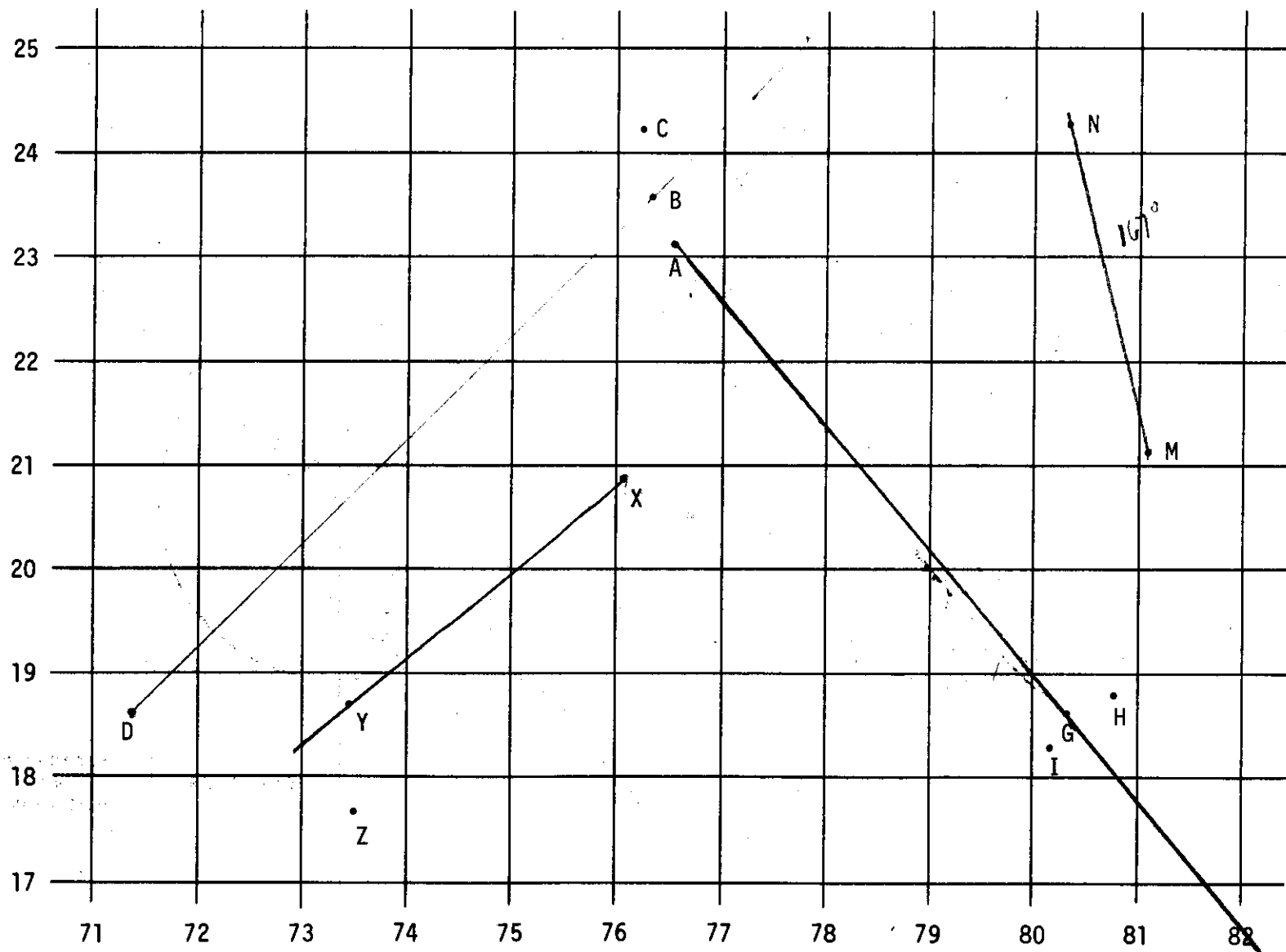
AZIMUTH DIRECTION LINE

AZIMUTH ANGLE 205°

(A) AZIMUTH ANGLE 180° OR LESS;
BACK AZIMUTH ANGLE EQUALS
AZIMUTH ANGLE PLUS 180°.
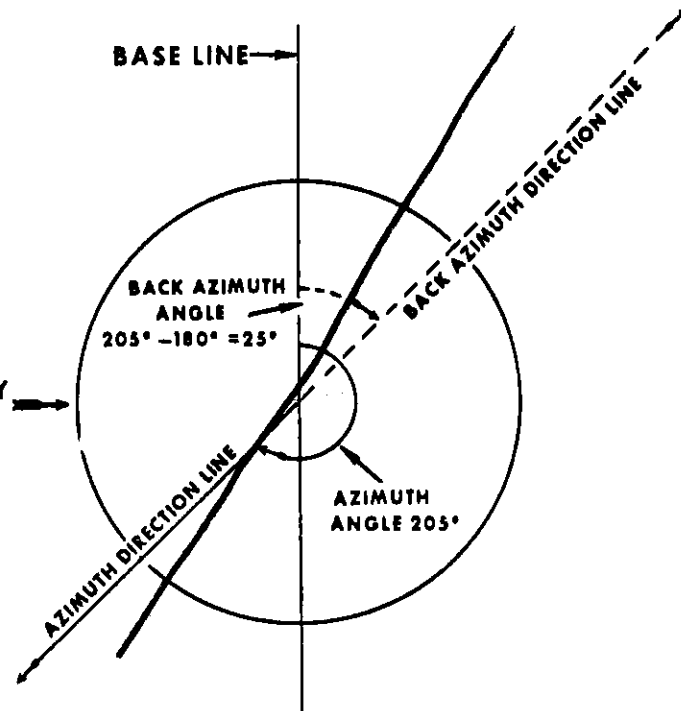
(B) AZIMUTH ANGLE MORE THAN 180°;
BACK AZIMUTH ANGLE EQUALS
AZIMUTH ANGLE MINUS 180°.

Panel 4-2   DETERMINING BACK AZIMUTH ANGLES

Panel 4-4

(1) Index hole over <u>horizontal</u> grid line.

(2) Read azimuth from <u>special scale</u> over same grid line.

COURSE LINE

Ⓑ

Ⓐ
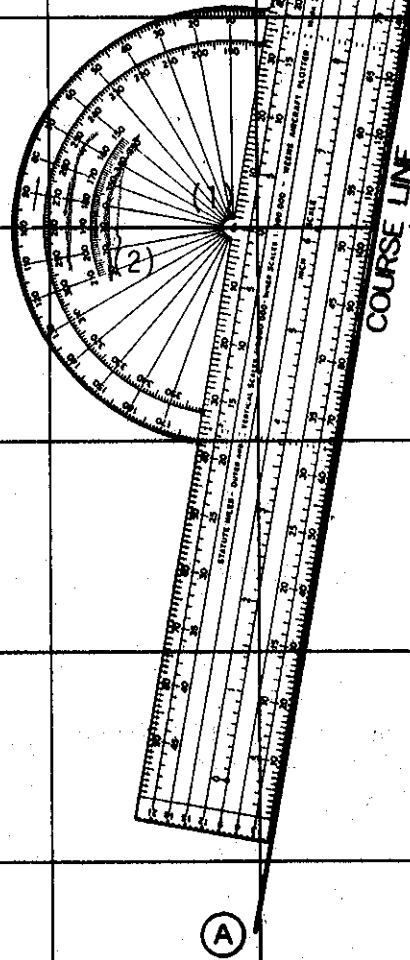
1. FROM A TO B, READ INNER SPECIAL SCALE (10°)

2. FROM B TO A, READ OUTER SPECIAL SCALE (190°).

<u>NOTE.</u> REVERSING PLOTTER POSITION FROM LEFT TO RIGHT
SIDE OF THE COURSE LINE DOES NOT AFFECT READING.

SELF EVALUATION EXERCISE
Part V

This exercise will test what you have learned from this programed text. Read each question carefully and select the correct answer.

Use <u>Lipan</u> map.

1. What is the value of the Grid Declination?

   a. 8°59' east
   b. 8°31' east
   c. 8°59' west
   d. 0°28' east

2. What is the back azimuth of a given azimuth of 060°?

   a. 120°
   b. 240°
   c. 340°
   d. 060°

3. Match the following.

   GN

   a.   b. ★   c.

   _C_ Magnetic North   _a_ Grid North   _b_ True North

4. Match the following.

   a. Compass direction of Magnetic North   3
   b. Vertical grid lines on a map   1
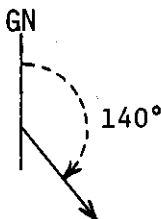   c. Earth's North Pole   2

       GN   ★

   1.   2.   3.

5. What is the G-M angle of the Lipan map? ___8°59'___

6. The following diagram illustrates a (Magnetic) (True) (~~Grid~~) azimuth of
__140°__ .

GN

140°

7. Determine the back azimuths of the directions listed below.

   a. Grid azimuth = ~~45°~~ 140°; grid back azimuth = __225°__.
   b. Magnetic azimuth = 125°; magnetic back azimuth = __305°__.
   c. True azimuth = 304°; true back azimuth = __124°__.

X 8. What is the azimuth from the Live Oak Church, grid square 8503, to the
   Gravel Pit in grid square 8305? ~~131°~~ __311°__ clockwise

9. Plot a grid azimuth of 41° from bench mark (BM) 823 (coordinate 835 081).
   Plot a grid azimuth of 145° from the school in the town of Brazos (coor-
   dinate 8255 1405). What terrain feature do you find at the intersection
   of these two azimuths?

   a. Hill
   (b) Saddle
   c. Depression

10. What is the grid azimuth from the Progress School (grid square 8122) to
    the Fairview Church (grid square 8220)? __164°__

X 11. Draw a Declination Diagram showing a magnetic declination of 5° east, and
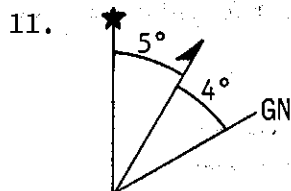   a G-M angle of 4° west.

12. What is the magnetic declination of the Lipan map? __9° 27' east__.

    8 59'
    28
    8 87
    60
    9° 27'

31

ANSWERS TO SELF EVALUATION EXERCISE – PART V

1. d.   0°28' east

2. b. – 240°

3. c. Magnetic North; a. Grid North; b. True North

4. a.   3; b.   1; c.   2

5. 8°59' east

6. Grid 140°

7. a.   225°; b.   305°; c. 124°

8. 311°

9. b. Saddle

10. 164°

11.

12. 9°27' east (0°28' + 8°59' = 9°27')