The wind angle 58° is obtained either mentally or by use of the computer with step (a). By applying the law of sines to the wind triangle of fig. 65 step (b) is as shown in fig. 66.

Result: W.C.A. = −7° (wind from left)

Relative wind angle
we = 58° − 7° = 51°
GS = 192 kt

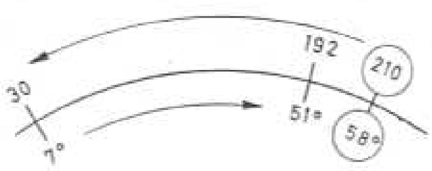

Fig. 66

12.2.3 Determination of Wind from Drift and Ground Speed

If drift and ground speed can be determined during flight, direction and speed of the wind may be calculated by means of the ARISTO AVIAT 610 and 615. In this problem the following parts of the wind triangle are known:

Heading (T.H.)
Air speed (T.A.S.)
Ground speed (GS)
Drift (Dr)

When the given parts of the wind triangle are studied it will be noticed that neither one of the two given sides T.A.S. and GS lies opposite the given angle (drift). Therefore, the law of sines is not directly applicable. On the computer the drift angle is included between air speed and ground speed. Therefore, to solve this problem the ∢ sin scale must be rotated until the angular value of drift is included as difference between the angle readings lying opposite the air speed and ground speed. Thereby the normal setting is obtained again: wind speed and drift, air speed and wind angle, ground speed and relative wind angle are respectively opposite. Accordingly the wind speed is read from the outer scale opposite the drift on the sine scale and the wind direction may then be obtained from the relative wind angle and the true heading. If, in problems of this kind, the ground speed is less than the air speed the value of the relative wind angle will be less than 90°. In the case of a tail wind the relative wind angle will be larger than 90°; therefore, the obtuse angle must be read from the ∢ sin scale. The wind direction is obtained as follows:

Setting: Set true heading over the aircraft index in the central part on the back of the AVIAT.
Set the hairline of the double cursor over the relative wind angle — to the left of the aircraft index in the case of positive drift, to the right of the aircraft index when drift is negative — on the black inner scale.

Reading: Read wind direction under the hairline from the compass rose.

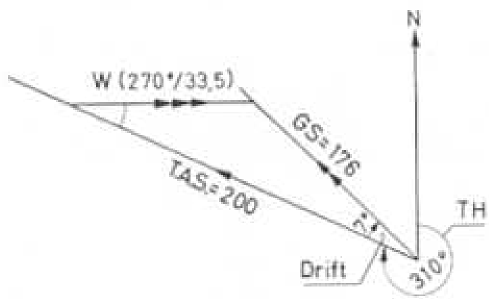

Fig. 67

Example 1:

TH = 310°
T.A.S. = 200 kt
GS = 176 kt
Dr = + 7°

Required: Wind direction and speed

GS smaller than T.A.S: relative wind angle less than 90°.
Drift +: wind from the left.

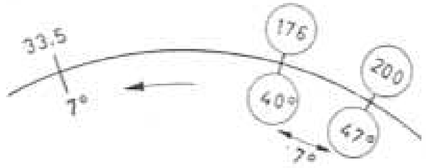

Fig. 68

Setting and reading procedure:

1. Turn ∢ sin scale until an angular difference of 7° on this scale corresponds with the interval between the speed 176 and 200. This is obtained when on the ∢ sin scale 40° is under 176 on the outer scale and 47° is under 200, respectively.
2. Read wind speed 33.5 kt from the outer scale over the drift of 7° on the ∢ sin scale
3. Read the relative wind angle of 40° from the ∢ sin scale under the ground speed of 176. (The acute angle is taken since there is a head wind; ground speed is less than air speed.)
4. Set true heading 310° over the aircraft index. Turn hairline of the double indicator towards the left (wind from left!) until the hairline coincides with 40° (relative wind angle) on the black inner scale. Then read under the hairline wind direction 270° (W) from the compass rose (fig. 69).

Result: Wind 270°/ 33.5 kt

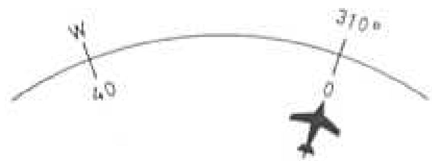

Fig. 69

Example 2:

Given: TH = 50°
T.A.S. = 190 kt
GS = 218 kt
Dr = − 5°

Required: Wind

GS greater than T.A.S., relative wind angle more than 90°.

Drift: wind from the right.

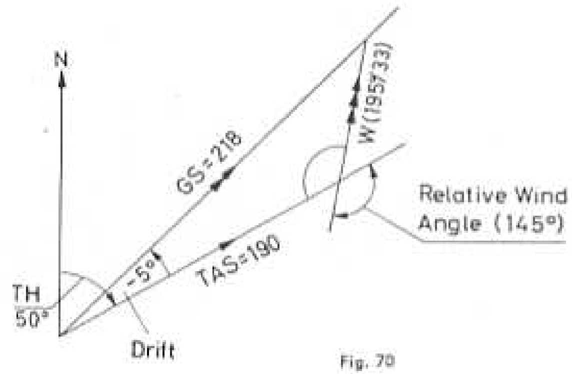

Fig. 70

For the solution fit angular difference of 5° between 190 and 218. (For convenience it is advisable to set the hairline of the cursor over 218.)

Result: Wind speed = 33 kt
Relative wind angle = 145°
Wind direction = 195°
Wind 195°/33 kt

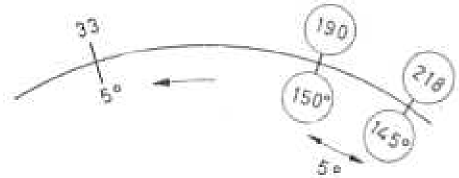

Fig. 71

12.2.4 Calculation of Drift and Ground Speed

Given: TH
T.A.S.
Wind

Required: Dr
GS

In practice the solution of this problem (DR navigation by computation) by means of the computer is of little importance. This is particularly true if several true headings are flown in succession (e. g. when bypassing a thunderstorm). In this case it is easier to solve the whole problem graphically on the chart since, even if Dr and GS have been calculated with the computer, the DR position will be determined by plotting the headings and distances in the chart anyway.

In solving this problem by means of the ARISTO AVIAT 610 and 615, the law of sines cannot be directly applied, just as in the case of wind determination from DR and GS, since the given angle (relative wind angle) does not lie opposite one of the given sides (air speed or wind speed), but is included between them. For the solution the relative wind angle must be fitted between the wind speed and the air speed. Then the drift is read from the ∢ sin-scale under the wind speed on the outer scale, and the ground speed over the relative wind angle. For convenience it is advisable to start with setting the relative wind angle over the air speed and then to add to the former the angular value which is read under the wind speed. Repeat this by trial and error method until the correct angle is found.

Example:

Given: TH = 120°
T.A.S. = 210 kt
Wind = 250°/26 kt
(Relative wind angle = 130°)

Required: Dr and GS

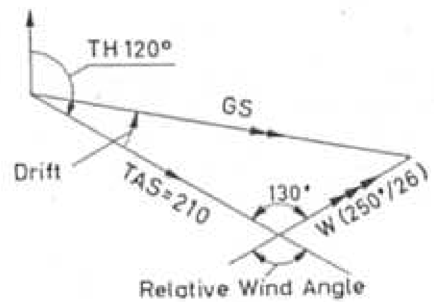

Fig. 72

Setting: The relative wind angle of 130° is fitted between 26 (wind speed) and 210 (T.A.S.) if 135° is under 210 and 5° is under 26. Then GS of 227 kt read over 130°.

Result: Dr = −5° (wind from right)
GS = 227 kt

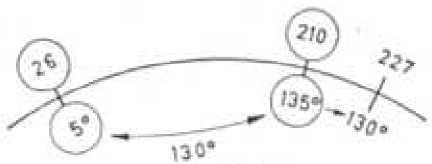

Fig. 73

12.2.5 Calculation of the Cross Wind and Course Wind Components

When taking off from or landing on a runway it is in many cases important to know the cross wind and/or head or tail wind components. For the solution by means of the ARISTO AVIAT the angular difference between the wind direction and the true direction of the runway is first determined.

Setting: Set 90° on the ∢ sin-scale under the wind speed on the outer scale.

Reading: Over the angular difference between wind direction and direction of the runway on the ∢ sin-scale read the cross wind component from the speed scale and over the complement of the angular difference read the head or tail wind component.

Example 1:

Direction of runway 265°
Wind 330°/30 kt
Wind angle 65° (head wind!)
Complement of wind angle 25°

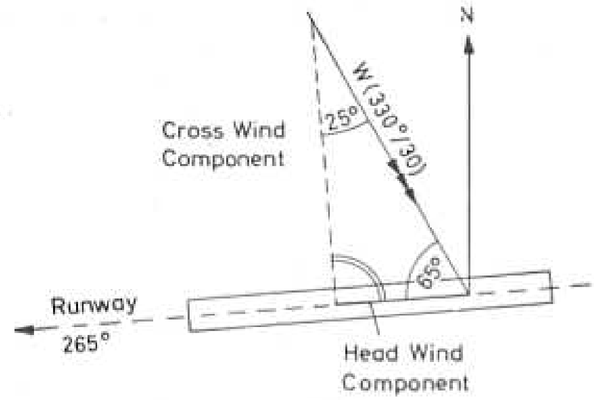

Fig. 74

Result:

Cross wind component 27.2 kt
Head wind component 12.7 kt

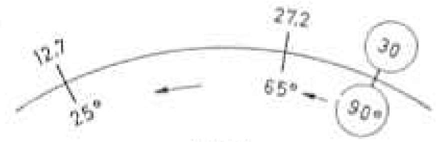

Fig. 75

Example 2:

Direction of runway 075°
Wind 200°/40 kt
Wind angle 125° (tail wind!)
Complement of wind angle 35°

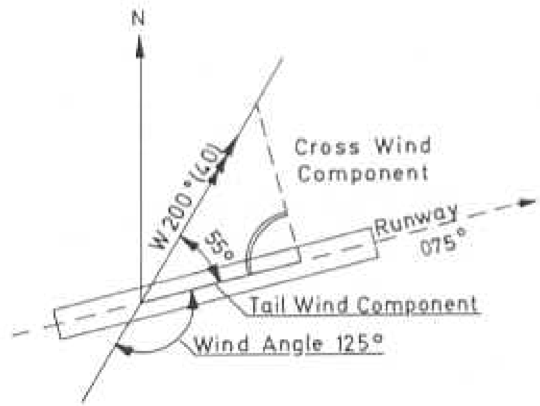

Fig. 76

Result:

Cross wind component 32.7 kt
Tail wind component 23 kt

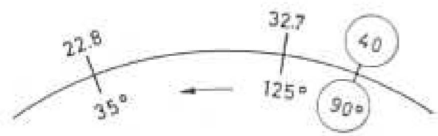

Fig. 77

12.2.6 Calculation of Drift from Beam Displacement (Z_n) or from Cross Wind Component (V_n)

(Pressure Pattern Navigation, see par. 8.1)

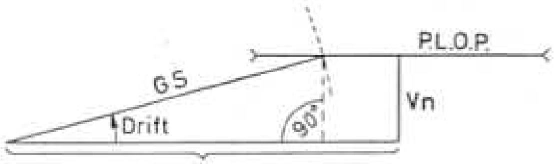

Fig. 78

Given: Gross wind component (V_n) and GS

Required: Drift

As will be seen from fig. 78 the drift may be determined by means of the law of sines:

$$\frac{GS}{\sin 90^\circ} = \frac{V_n}{\sin Dr}$$

Example 1:

Given: $V_n = +29$ kt
GS = 205 kt

Required: Drift

Result: Drift + 8°

Fig. 79

Example 2:

Given: Beam displacement
$Z_n = +34$ kt
GS = 210 kt
Time elapsed between the measurements of D-values
90 min

Required: Drift

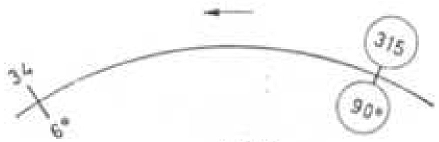

Fig. 80

From the ground speed compute the distance flown between the points where the measurements were taken (315 NM, see par. 6.2.3). Then calculate drift using the law of sines.

Result: Drift + 6°

12.3 Calculation of Departure

Departure is the distance expressed in nautical miles between two meridians at a given latitude. The approximation for the calculation of departure is:

Departure = difference in longitude Δl (in minutes) × cosine latitude φ,

or, written as a proportion:

$$\frac{\text{Departure}}{\cos \varphi} = \frac{\Delta l}{1}$$

$$\frac{\text{Departure}}{\sin (90^\circ - \varphi)} = \frac{\Delta l}{\sin 90^\circ}$$

Example: Compute departure between 5°E and 8°E at 54°N
$\Delta l = 3^\circ = 180'$
$90^\circ - \varphi = 90^\circ - 54^\circ = 36^\circ$

Result: 106 NM

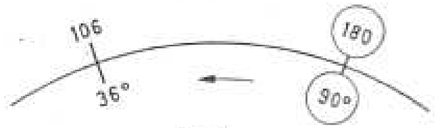

Fig. 81

12.4 Calculation of the Conversion Angle (C.A.)

The approximate formula for finding the conversion angle is:
C.A. = 1/2 difference in longitude Δl × sine of mean latitude φ,

or written as a proportion:

$$\frac{C.A.}{\sin \varphi} = \frac{1/2\ \Delta l}{\sin 90^\circ}$$

Example: Location of transmitter Lat 51 °N
Long 8 °E
DR position of aircraft Lat 53 °N
Long 4 °W
Difference in longitude 12°
(hence 1/2 Δl = 6°)
Mean latitude 52°

Result: C.A. = 4.7°

Fig. 82

12.5 Calculation of True Bearings

Given: Relative bearing and true heading.

Required: True bearing of station from A/C and true bearing of A/C from station (to be plotted).

Setting: Set TH on compass rose over the aircraft index. Turn hairline of double indicator over the angular value of the relative bearing on the black inner scale marked 0° to 360°.

Reading: Read under the hairline from the compass rose the true bearing of station from A/C and under the other hairline of the indicator read the true bearing of A/C from station.

Example: Relative bearing = 234°
TH = 78°

Result: True bearing 312°
to be plotted 132°

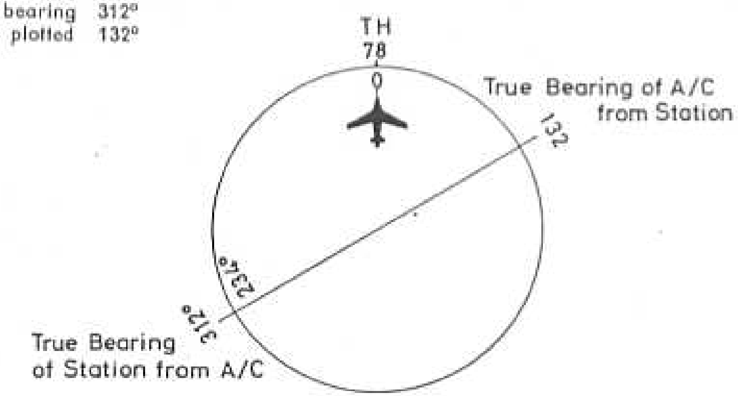

Fig. 83

13. Glossary of Navigational Terms

Altitudes

a) Absolute Altitude is the true altitude of an aircraft above ground.

b) Density Altitude is the altitude in the Standard Atmosphere corresponding to the flight level density.

c) Pressure Altitude is the altitude in the Standard Atmosphere corresponding to the flight level air pressure. It is indicated on the pressure altimeter with its subscale set to 1013.2 mb or 29.92 inches of mercury.

d) QNH Altitude is the altitude indicated by a pressure altimeter with its subscale set to the relevant QNH.

e) True Altitude is the height above a fixed datum (usually mean sea level).

Compressibility Error

is the error caused by the fact that the air is a compressible gas. This error attains appreciable values only at speeds higher than 200 kt and in higher altitudes.

Drift

is the angular difference between the heading and the track made good.

D-Value

is the difference (usually in feet) between the absolute and the pressure altitude.

Isohypses

Contour lines in 500 mb weather charts with 200 ft intervals between isobaric surfaces.

Mach Number

is the ratio of true air speed to the speed of sound.

Pressure Pattern Navigation

is a system of navigation based on the distribution of the atmospheric pressure between the point of departure and the point of destination. Its typical applications are the minimum flight path, the single heading flight and the determination of the beam displacement and drift in flight by comparison of the absolute altitude, as shown on the radio altimeter, with pressure altitude.

Relative Wind Angle

is the angle between the direction from which the wind is blowing and the direction into which the aircraft is heading.

Speeds

a) Indicated Air Speed (I.A.S.) is the reading of a particular air speed indicator.

b) Rectified Air Speed (R.A.S.) or Calibrated Air Speed (C.A.S.) is the indicated air speed corrected for instrumental and installation errors.

c) True Air Speed (T.A.S.) is the air speed relative to the surrounding air undisturbed by the aircraft's motion. It is determined from the rectified (calibrated) air speed by applying a correction for the density error and — at higher speeds — for the effects of compressibility. The density error is caused by deviation of the flight level pressure and temperature from the standard sea level values upon which the calibration of air speed indicators is based.

d) Effective True Air Speed (E.T.A.S.) is used in pressure pattern navigation for determining the beam displacement (Z_n) when a change of heading has occured between the two sets of altimeter readings. First the air distance, i. e. the direct distance between the Dr or ground position at the first set of altimeter readings and the air position at the second set of altimeter readings, is measured. Then, this value is divided by the time elapsed between the two sets of altimeter readings to obtain the effective true air speed.

e) Ground Speed is the speed of an aircraft over the earth's surface.

Tracks, Courses and Headings

a) True Track (Course) is the angle between true north and the path of an aircraft over the ground. **Required Track** is the direction which an aircraft is intended to follow. **Track Made Good (T.M.G.)** is the actual path over ground covered by an aircraft.

b) True Course - Co (T), or True Heading - T.H. - is the angle between true north and the longitudinal axis of an aircraft.

c) Magnetic Course - Co (M), or Magnetic Heading - M.H. - is the angle between magnetic north and the longitudinal axis of an aircraft. The angular difference between the true and the magnetic heading is the **Variation.**

d) Compass Course - Co (C), or - Compass Heading - C.H. - is the angle between the direction of magnetic north on the compass card and the longitudinal axis of an aircraft. The angular difference between magnetic and compass course or heading is the **Deviation** caused by the influence of magnetic fields in the aircraft other than that of the earth.

Wind Angle

is the angle between the direction from which the wind is blowing and the direction of the required track or the track made good.

Wind Correction Angle

is the angle between the required track and the heading to be steered. In identical wind triangles the wind correction angle has the same numerical value as the drift but the opposite sign (e. g. W.C.A. +, when the Drift is Port, i. e. minus).