When setting the temperature its algebraic sign must be observed. For clarity only the values 20°, 40°, etc. are numbered. By aid of the 5°-lines one degree can be estimated. On the altitude scale every interval represents 1000 ft; intermediate values can be located to 100 ft by estimate. On the metric altitude scale each interval represents 200 m. The two pressure altitude scales, in conjunction with the index hand, facilitate conversion of ft to km and vice versa.

Example:

Given: Rectified air speed (R.A.S.) 170 kt

Corrected outside air temperature −5°C

Pressure altitude 9000 ft

Required: True air speed (T.A.S.)

Result: T.A.S. = 194 kt

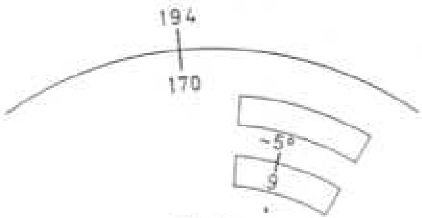


Fig. 27

### 9.1.2 Calculation of Rectified Air Speed (R.A.S.)

Given: True air speed (T.A.S.) = 230 kt

Outside air temperature −21 °C

Pressure altitude 6800 m

Required: Rectified air speed (R.A.S.)

Temperature correction −5°

C.O.A.T. − 26° C

Setting: As in par. 9.1.1

Reading: Read rectified air speed from scale (c) opposite true air speed on the adjacent scale (b)

Result: R.A.S. = 160 kt

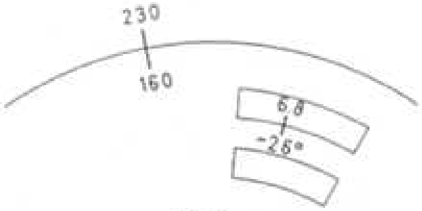


Fig. 28

### 9.1.3 Compressibility Correction

Computations of true air speed with the ARISTO AVIAT 617 and 618 disregard the error due to compressibility of the atmosphere. Such errors only take on major proportions at speeds above 200 kt and in higher altitudes. The calibration of the air speed indicator takes the effect of compressibility at sea level into account. Aircraft flying at speeds that make it necessary to compensate for compressibility usually carry special correction tables or speed diagrams in which the corrections are incorporated. These correction tables or diagrams, compiled by builders of aircraft from data collected in trial flights and furnished together with the performance curves, enable an accurate determination of the true air speed corrected for compressibility. There are also now available true air speed indicators which automatically register the true air speed corrected for compressibility. Still another approach is offered by the machmeter installed in jet planes, and consists in solving for the true air speed from:

$$\text{Mach Number} = \frac{\text{True Air Speed}}{\text{Speed of Sound}}$$

In the absence of better facilities, the correction factors for various speeds and altitudes can be determined from the following table:



| Pressure Altitude in ft | Rectified Air Speed in kt | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 |
| 10,000 | 1.0 | 1.0 | 0.99 | 0.99 | 0.98 | 0.98 | 0.97 | 0.97 |
| 20,000 | 0.99 | 0.98 | 0.97 | 0.97 | 0.96 | 0.95 | 0.94 | 0.93 |
| 30,000 | 0.97 | 0.96 | 0.95 | 0.94 | 0.94 | 0.91 | 0.90 | 0.89 |
| 40,000 | 0.96 | 0.94 | 0.92 | 0.90 | 0.90 | 0.87 | 0.87 | 0.86 |
| 50,000 | 0.93 | 0.90 | 0.87 | 0.86 | 0.86 | 0.84 | 0.84 | 0.84 |

To find the true air speed corrected for compressibility, the correction factor is read against the rectified air speed and the pressure altitude from the foregoing table. The true air speed computed as usual (see par. 9.1.1) is then multiplied by the correction factor. The result will not be strictly accurate, since it disregards the variation of temperature at flight level (Pressure Altitude) in comparison with the standard atmosphere.

Example: Rectified air speed 320 kt
Pressure altitude 20000 ft
Observed outside air temperature −6°.

Estimated T.A.S. 430 kt (for obtaining temperature correction).

Temperature correction −17°.

Add this value to the observed outside temperature to obtain the corrected outside air temperature −23°C.

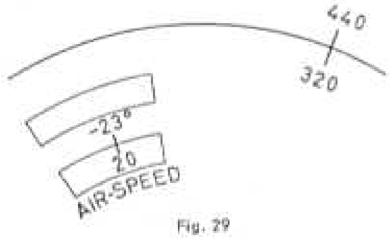


Fig. 29

True air speed (without compress. corr.) 440 kt.

Correction factor 0.97.

0.97 × 440 = 427 kt (true air speed corrected for compressibility).

### 9.1.4 Calculation of Speed of Sound and Mach Number

From the relation between Mach number, true air speed and speed of sound mentioned in par. 9.1.3 any one of the values may be readily obtained from the other two given ones.

#### 9.1.4.1 Mach Number

For the determination of the Mach number there are two marks on the scales appearing in the window for air speed calculations, one of which is labelled M (km/h) in the window for pressure altitude in km and the other labelled M (kt) in the window for pressure altitude in ft; the M (kt) mark is best found by turning the inner disk anti-clockwise starting from zero on the red pressure altitude scale.

Setting: Set corresponding mark M (km/h) or M (kt) against outside temperature (C.O.A.T.) at flight altitude.

Reading: Read under true air speed on outer scale the Mach number from the rotatable scale (c).

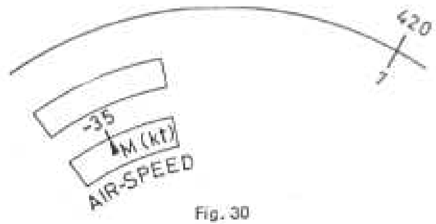


Fig. 30

Example: True air speed 420 kt, outside temperature at flight altitude − 35° C.

Result: Mach number 0.7

### 9.1.4.2 Speed of Sound

Since the speed of sound changes with the temperature and $C_s = \frac{\text{T.A.S.}}{M}$ expresses the relation between these factors, the speed of sound can be found by setting the M (kt)-mark or M (km/h)-mark opposite the outside temperature as in the par. 9.1.4.1.

Setting: Respective M-mark opposite C.O.A.T. at flight level.

Reading: Opposite the mark $\boxed{10}$ of the minute scale read the speed of sound on the stationary outer scale.

Example: C.O.A.T. at flight level $-35°$ C.

Result: Opposite $\boxed{10}$ read the speed of sound 600 kt.

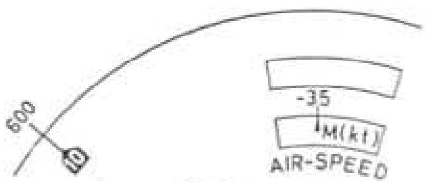

Fig. 31

### 9.2 Calculation of Air Speed with ARISTO AVIATJET 647

Air speed computation, at high speeds and at high altitudes, is simplified with the ARISTO AVIATJET 647. Air compressibility is automatically taken into account and the increase in outside temperature, resulting from compressibility-heating, can be read in the aperture TEMP. RISE. The true outside temperature can therefore be derived. From the initial setting of CAL. AIR SPEED against PRESS. ALTITUDE, the Mach number is apparent. To read true air speed a further setting of the rotating index suffices.

### 9.2.1 Calculation of True Air Speed T.A.S.

Known: Indicated air speed $V_a$ (C.A.S.) in kt
Indicated temperature, °C
Pressure altitude in ft.

Required: True air speed T.A.S.
Mach number
Temperature rise
Corrected outside temperature.

Setting: Set indicated air speed C.A.S. in the grey edge-field to the pressure altitude on scale (f). Bring the three line indicator over the intersection of the reference spiral and the temperature curve (i) for the indicated temperature.

Note: Rotary indicators are available for $C_T = 1.0$, 0.95 and 0.8. $C_T$ is the coefficient of temperature recovery. The solid lines are valid for the standard atmospheric temperature at approximately 35 000 ft., $-56.5°$ C. The dotted lines refer to standard temperature at sea level, $+15°$ C. For $C_T = 1.0$ the single intersecting line of the rotary indicator is used.

Reading: Read true air speed on the TRUE AIR SPEED scale (x) under the rotary indicator. Beneath the index line of the rotating indicator read temperature increase on scale (z) TEMP. RISE. The Mach number is shown under the index line at the window marked Mach.

Note: The temperature rise is always read with reference to $C_T = 1.0$ If calculated with the curves of the cursor, the result is the temperature rise – from Temp. Rise x $C_T$.



Example: Sub-Sonic flight. $C_T = 1.0$

Given: $V_a = 325$ kt
Press. Alt. = 22 000 ft
In. Temp. = $+10°$ C

Required: T.A.S. = 455 kt
Temp. Rise = $+27°$
Outside temperature:
$10° - 27° = -17°$
Mach no. = 0.727

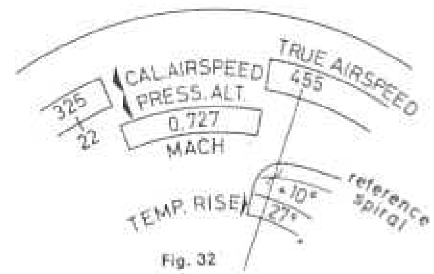

Fig. 32

Example: Super Sonic Flight. $C_T = 1.0$

Given: $V_a = 437$ kt
Press. Alt. = 40000 ft
Ind. Temp. = $+25°$ C

Required: T.A.S. 772 kt
Temp. Rise = 78°
Outside temperature:
$= +25° - 78° = 53°$ C
Mach = 1.34

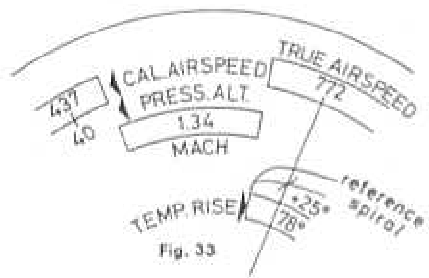

Fig. 33

For $C_T = 0.8$, the solid cursor curve identified as 0.8 is set to the $+25°$ C intersection of the reference spiral. The T.A.S. = 797 kt can then be read, together with the temperature rise 82° C x 0.8 = 65.6° C.

## 10. Altitude Calculations

### 10.1 Calculation of True Altitude

Altimeters are calibrated according to the conditions of standard atmosphere. Deviations of the actual air pressure from standard values are compensated by the respective altimeter setting (QNH or QFE). However, temperature variations, another source of erroneous indication, cannot be compensated by an altimeter setting as in the case of pressure deviations. For calculating true altitude the window scale (g) labelled ALTITUDE is used.

Given: Pressure altitude 17 000 ft
QNH – altitude 17 500 ft
Corrected outside air temperature $-10°$ C.

Required: True altitude

Setting: Set pressure altitude (17 000) against corrected outside air temperature ($-10°$ C).

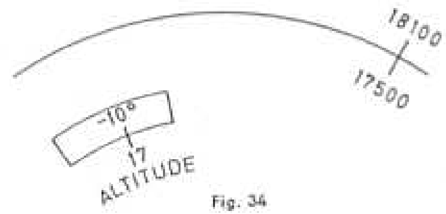

Fig. 34

Reading: Read true altitude (18100) on the outer scale (T.ALT.) against QNH ALT. (17 500) on the inner scale (QNH ALT.).

Result: 18100 ft.

## 10.2 Calculation of Density Altitude

### 10.2.1 With Aviat models 610 · 613 · 615 · 617 · 618

Setting: Set corrected outside air temperature on the red scale (f) labelled C.O.A.T. against PRESS. ALT in km in the upper part of the window or over PRESS. ALT in ft in the lower part.

Reading: Follow the red arrow from the AIR SPEED scales to the right and read density altitude on the sub-scale in km against the index at the upper edge of the window or in ft against the index at the lower edge of the window labelled DENSITY ALT.

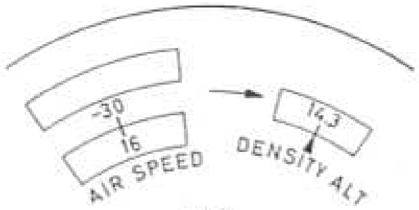


Fig. 35

Example:

Given: Pressure altitude 16000 ft, C.O.A.T. — 30° C

Required: Density altitude

Result: 14300 ft

### 10.2.2 Density Altitude with AVIATJET 647

The red scale (h), DENSITY ALTITUDE × 1000, at the labelled aperture, is associated with the red temperature scale in the unfigured range of scale (f), CAL. AIR SPEED.

Setting: Set the pressure altitude on scale (f), labelled PRESS. ALTITUDE, under the indicated outside temperature C.O.A.T., using the red temperature scale.

Reading: The Density Altitude is read on scale (h) at the window.

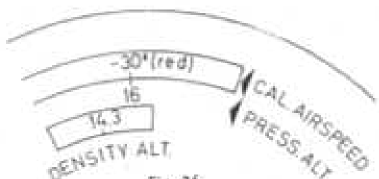


Fig. 36

For the previous example of par. 10.2.1, the illustration, fig. 36, shows a similar setting and reading. Following international usage heights are given in feet.



## 11. Graphic Solution of Triangles with the ARISTO AVIAT 613, 617, 618, 647

The wind triangle face of the ARISTO AVIAT 613, 617, 618 and 647 is used in conjunction with the diagram slide (o) and the rotary plotting surface (n) for solving general problems in plane trigonometry. The radiating drift lines together with the concentric speed arcs of the slide are used for wind triangle problems. The rectangular grids on the diagram faces B, G and H are applied to the specific case of the right angled triangle

**Use only soft lead pencils or a fountain pen for marks on the plotting surface — never indelible lead, crayons or ball point pencils.**

### 11.1 Wind Triangle Problems

With the ARISTO AVIAT the approach to these problems consists of forming a clear conception of the given elements and their correct relationship in the solution design. Fig. 37 shows the wind triangle in all its details and is a key to the terms and symbols commonly used.

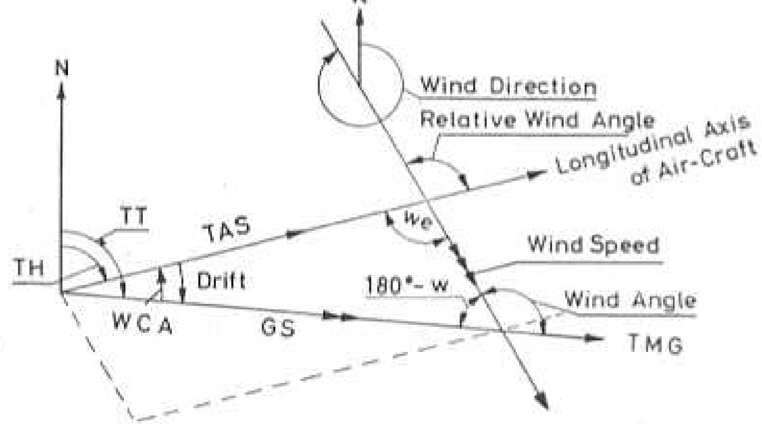


Fig. 37

#### 11.1.1 The Wind Triangle

The wind triangle results from the vectorial combination of velocities, namely the true air-speed T.A.S. and heading as well as the wind speed and direction; the resultant of these two components is the ground speed GS along the track made good T.M.G.

If the aircraft drifts to the right, or starboard, the drift is plus; if to the left, or port, the sign is minus.

If the aircraft is headed to the right of the track, the W.C.A. (wind correction angle) is plus, if headed to the left, the sign is minus.

On the ARISTO AVIAT the wind triangle takes shape before the user's eye. On the diagram slide the drifts are indicated by a fan of diverging rays which, if traced back, would have their origin at a point A beyond the slide.

The center line is the ZERO axis and the rays to the right and left thereof give the various drift angles in degrees. The concentric arcs drawn about A as their center represent the speeds (km/h or knots), which are marked on them, increasing outward from A = Zero.

When the wind vector is plotted with its origin at the center bore of the plotting surface, the indicator signifies the flight courses, viz. the center axis the true heading and the rays the track over ground. The angle between the Zero axis and the respective ray is the angular value of the drift, one degree from ray to ray, every fifth ray numerated.

Each diagram on a slide includes only that section of the complete system of radiating rays and concentric arcs which corresponds to its individual range of speed.

The diagram in fig. 38 demonstrates the graphic construction of the wind triangle with the ARISTO AVIAT when the given elements are the true heading, the true air speed and the wind data. The true air speed on the Zero axis of the diagram slide is brought under the center bore of the plotting surface. The wind vector is then plotted from the wind speed and direction, with its origin at the center bore. The Zero axis is assumed as the true heading and the ray which passes through the terminal point of the vector is the resultant which completes the triangle and indicates the true track, the ground speed being readable at its intersection with the speed arc and terminal point of the wind vector.

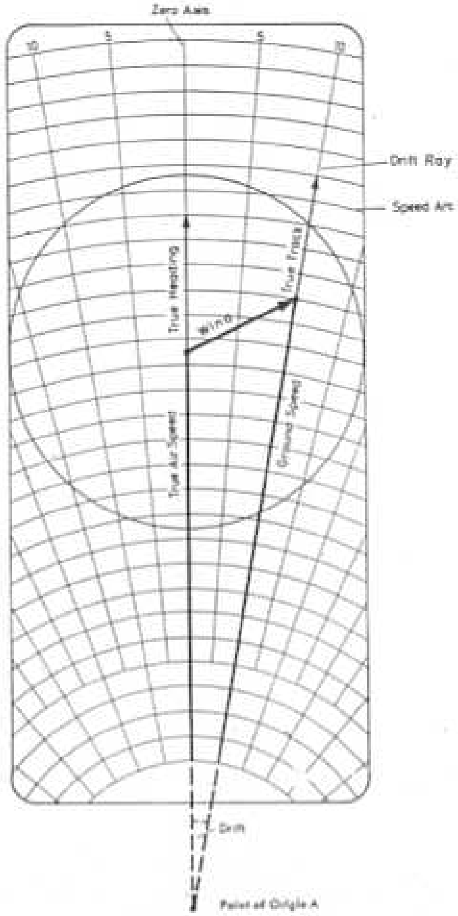


Fig. 38 The Wind Triangle on the ARISTO AVIAT

The ARISTO AVIAT 613, 617 and 647 have a rotary indicator. With these computers the wind vector does not need to be drafted but is established mechanically by setting the indicator to the wind direction on the circle limb and locating the wind speed on the indicator graduation. This is the terminal point of the wind vector where the ground speed and the drift can then be read from the lines of the diagram slide.

Dependent upon the air speed ranges selected, the diagram scales listed in par. 2 have systems of graduated lines, each of which is related to the scales of wind velocity engraved on the rotary indicator. To avoid errors in pairing scales, the scales of the diagram slide are marked with identical symbols, △, ○, □, × as are seen on the rotary indicator.



### 11.1.2 Determination of Drift Angle and Ground Speed

Given: True heading
True air speed
Wind direction and velocity

Required: Drift angle and ground speed

Drafted Solution:

(1) Along a line from A in direction of the true heading lay off the true air speed.
(2) From point B, so determined, plot the wind vector downwind to obtain point C.
(3) Angle BAC is the drift angle (Dr) and the line AC gives the ground speed.

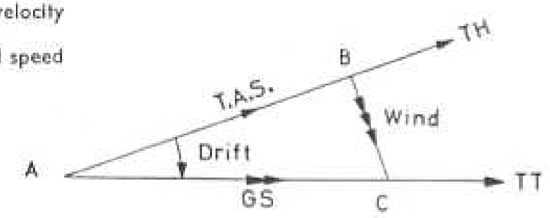


Fig. 39

Computer Solution:

(a) Match the true heading on the azimuth circle with the TRUE INDEX mark. Shift the diagram slide so as to make the true air speed on its center axis coincide with the center bore in the plotting surface.

(b) From the center bore plot the wind vector **downwind** by help of the indicator using for the wind direction the **red** azimuth graduation.

(c) Under the end of the wind vector find the drift by means of the drift lines and the ground speed by means of the speed arcs of the diagram slide.

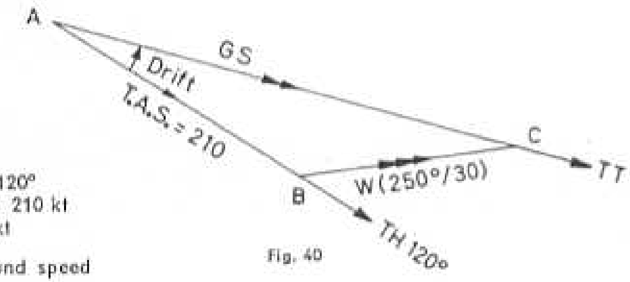


Fig. 40

Example:

Given: True heading 120°
True air speed 210 kt
Wind 250°/30 kt

Required: Drift and ground speed

Setting: 120° against TRUE INDEX (fig. 41) 210 kt under center bore of plotting surface

Reading: Under the wind speed 30 kt on the indicator scale read the drift — 6° on the black drift line and the ground speed 230 kt on the black speed arc.

The arc marked DRIFT RIGHT and DRIFT LEFT and numerated 0° to 50° in both directions from the TRUE INDEX is used for adding and subtracting the drift from the true heading to obtain the true track. Under the 6°-line of the left wing of the arc bearing the minus sign the reading for the true track gives 114°.

Users of the ARISTO AVIAT 618 with its blank plotting surface will find it somewhat tricky to plot the wind vector. They will employ the following method: Set the wind direction to the TRUE

INDEX. Move any convenient numerated speed arc of the slide under the center bore and lay off the wind velocity downward along the center axis. Mark the end point of the wind vector with a pencil-dot or cross. Now turn the true heading under the TRUE INDEX and continue as explained under (a) and (c).

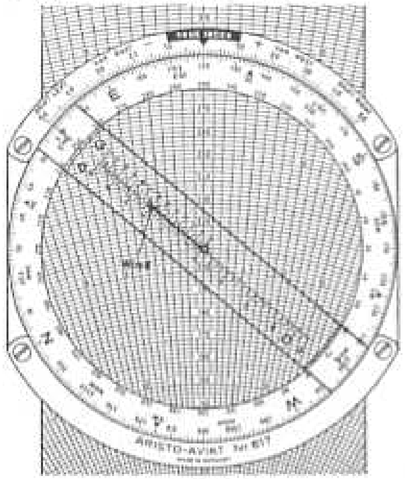

Fig. 41

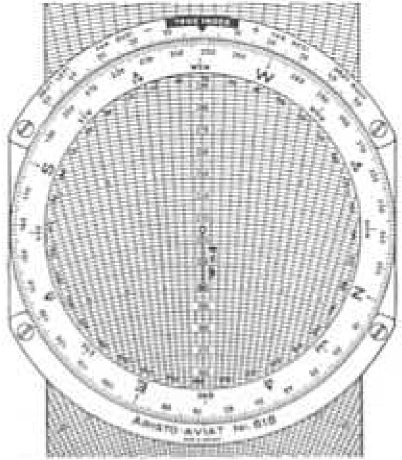

Fig. 42

Example:

Given: True heading and true air speed, as before, but wind 248°/26 kt

Required: Drift and ground speed

Setting:
(1) Wind direction 248° to TRUE INDEX (fig. 42)
(2) From center bore plot 26 kt downward (best done by placing the arc 126 or 226, for instance, under the center bore and marking the wind vector by a dot or cross at 100 or 200, respectively, along the numerated axis).
(3) True heading 120° to TRUE INDEX
(4) True air speed 210 kt under center bore

Reading: Under the plotted end point of the wind vector find the drift angle —5° and the ground speed 227 kt on the diagram slide.

### 11.1.3 Finding the Wind Correction Angle and the Ground Speed

Given: The true track (required track or track made good, respectively)
True air speed
Wind

Required: Wind correction angle and ground speed

Drafted Solution:

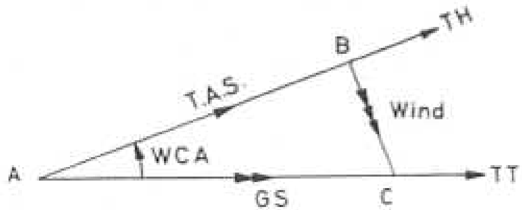


Fig. 43



(1) Plot direction of the true track.
(2) From some arbitrary point C on this line plot the wind vector upwind to obtain B.
(3) Swing an arc with B as its center and radius true air speed, intersecting the track to obtain A. Draw line AB. Angle BAC is the wind correction angle and line segment AC is the ground speed.

Computer Solution:

(a) Set true track to TRUE INDEX.
(b) Turn the indicator to the wind direction, in this case using the black azimuth graduation (the angle being upwind counting anti-clockwise).
(c) Shift the speed arc corresponding to the true air speed so as to coincide with the wind speed on the indicator.
(d) Read the wind correction at the same place. Read the ground speed under the center bore from the scale on the axis of the slide.

Example:

Given: True track 48°
Wind 350°/30 kt
True air speed 210 kt

Required: Wind correction angle and ground speed

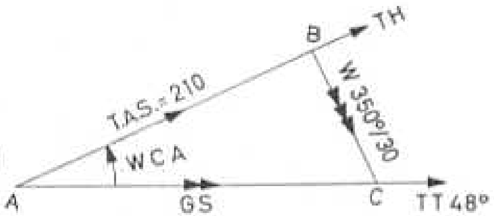


Fig. 44

Setting: 48° to TRUE INDEX (fig. 45)

Set the indicator to 350° on the black azimuth circle (being upwind). Adjust the speed arc labelled 210 of the diagram slide to the wind speed 30 kt of the indicator scale.

Reading: Under the plotted point read the wind correction angle —7°. Under the center bore read the ground speed 192 kt.

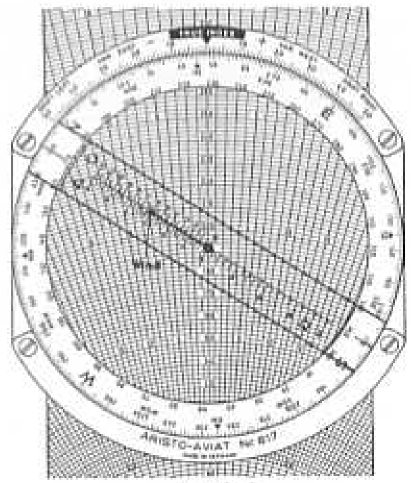

Fig. 45

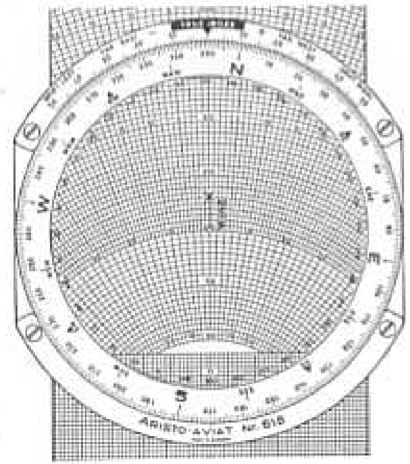

Fig. 46