POOLEYS PRODUCTS

INDEX

NOTES

INTRODUCTION

The 1988 models of this range of CRP computers incorporate several changes from previous models. Heavier grade materials are now employed in their construction, the obsolete Pressure Pattern latitude scale has been deleted and the slide now has graduations along the edges for measuring in inches, millimetres and nautical miles (to scales of 1:250,000 and 1:500,000). Minor changes to the layout and clearer numerals make for easier reading and use.

The various ways of using the computer described in this handbook, particularly the solving of triangle of velocity problems, are those employed in Commercial Aviation. These ways of usage, evolved from vast experience and knowledge of the problems involved are consistent in their application and solve all known problems. Many alternative ways of solving problems on the computer exist; mostly they are one-off solutions involving non-standard use of datums. In experienced hands "short cuts" may be acceptable but newcomers are strongly advised not to try them as the end result is usually confusion and frequently they are left with long term hang-ups about the computer.

SOLVING FOR HEADING (Hdg) AND GROUND SPEED (GS)
knowing WV, TAS and required Trk

Convert the wind speed to WV ratio.

Rotate the wind arm to set the **WIND DIRN** line over the wind direction on the outer compass rose. Holding the wind arm in place rotate the grided disc until the **HEADING INDEX** is opposite the Trk direction on the outer compass rose.

Under the WV ratio on the wind arm read off the drift. Further rotate the grided scale until this drift on the drift scale is now opposite the Trk direction on the outer compass rose.

Check the drift now under the WV ratio on the wind arm, as the last adjustment may have altered it.

(a) If it is the same as the drift opposite the track direction on the outer compass rose the computer is correctly set up. Read off hdg opposite the **HEADING INDEX** and the drift and GS ratio under the WV ratio on the wind arm.

(b) If it is not the same as the drift opposite the track direction on the outer compass rose rotate the grided scale until the new drift is opposite the Trk direction on the outer compass rose and check the drift now under the WV ratio on the wind arm. If necessary repeat until the drifts match. The computer is now correctly set up. Read off Hdg opposite the **HEADING INDEX** and the drift and GS ratio index under the WV ratio on the wind arm. Convert the GS ratio to GS.
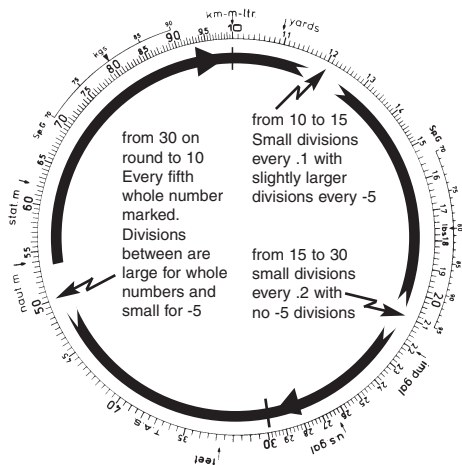
> *Example:* **TAS 230 kts, WV 000°(T)/40 kts, Trk 055°(T). What is Hdg°(T) GS and drift?**
> Calculate the WV ratio.
> *Rough check:* 40 divided by 240 = 0.133

Set 1 on the inner scale opposite 230 on the outer scale, opposite 40 on the outer scale read off the WV ratio of 0.174 on the inner scale.

SPACING The scale is not constant and the values of the various divisions are clarified on the diagram below.

from 30 on round to 10 Every fifth whole number marked. Divisions between are large for whole numbers and small for -5

from 10 to 15 Small divisions every .1 with slightly larger divisions every -5

from 15 to 30 small divisions every .2 with no -5 divisions

NUMBERING The actual numbers printed go from 10 to 95, with some omissions due to compression of the scale. By use of the cursor and the graduated scale it is possible to select any value from 10 to 99.9 but since there are only whole numbers printed on the scale any decimal point has be to mentally inserted. This gives great flexibility, for by mentally moving the decimal point to the right or left a position on the scale can be used to represent a whole range of numbers. For example the second small division to the right of 17 can be used to represent 17.4; 1.74; 17400; 0.00174 etc.

When performing calculations on the circular slide rule particular care has to be taken in the positioning of the decimal point in the final

Convert the GS ratio into a GS.

Example: **Hdg (T) 265, WV 210/35, TAS 290 kts.**
What is Trk and GS?

Calculate WV ratio.

Rough Check: 30 divided by 300 = 0.1

Set 1 on the inner scale against 290 on the outer scale, against 35 on the outer scale read off WV Ratio 0.12 on the inner scale.

Rotate the wind arm until **WIND DIRN** line lies over 210° on the outer compass rose.

Holding wind arm in place rotate grided disc until HEADING INDEX points to 265° on outer compass rose.

Under the WV ratio on the wind arm read off drift 6° Starboard and GS ratio 0.93.

Against 6° Starboard on the drift scale read off Trk 271°(T) on the outer compass rose.

Example: **Convert GS ratio to GS**
Rough Check: *0.9 x 300 = 270 kts*

Set 1 on the inner scale against 290 on the outer scale against 0.93 on the inner scale read of GS 271 kts on the outer scale.

Answer: **Trk 271° (T), GS 271 kts.**

SOLVING FOR WIND VELOCITY (WV)
knowing Hdg and TAS plus Trk and GS

From known TAS and GS calculate the GS ratio. Rotate the grided disc until the HEADING INDEX is opposite the Hdg direction on the outer compass rose. Read off opposite the known Trk on the compass rose drift on the drift scale.

Example: **462 ÷ 17.9.**
Rough Check   say, 500 ÷ 20 = 25

<u>*Set slide rule*</u>

Rough answer 25, therefore actual answer 25.8 (and not 258).

MULTIPLICATION

A multiplied by B can be written as A/1 = Answer/B.
On the circular slide rule this is set thus

Example: **0.015 x 0.26.**
Rough Check: Say, 0.02 x 0.2 = 0.004

<u>*Set slide rule*</u>

Rough answer 0.004, therefore actual answer 0.0039 (and not 0.039 or 0.00039).

In both division and multiplication the 10 (used as 1.0) played a key role as a constant. Because of its frequent use as a constant it has been highlighted in blue on both the inner and outer scales.

matching scale arm.

SOLVING FOR WIND VELOCITY (WV)
knowing Hdg and TAS plus Trk and GS

Proceed exactly as for the CRP-5 except that instead of marking the wind cross at the intersection of the drift and GS, the arm of the wind bar whose scale matches the slide scale, is rotated to pass through the point of intersection. Read off the wind direction on the window disc opposite the other arm of the wind bar and read off wind speed on the matching scale arm at the point of intersection of the drift and GS.

Try reworking the example given for the CRP-5 by this method.

CRP-9; WIND TRIANGLE PROBLEMS

The reverse side of the CRP-9 computer is arranged to solve the navigational triangle of velocities without the use of a slide. The principle is based upon 'similar triangles', the TAS being taken as unity (factor of 1) and the Wind and Ground Speeds are expressed as ratios of the TAS.

The large outer disc has compass rose around its edge. The smaller centre disc is grided in drift lines and GS ratios, at the top it has a HEADING INDEX either side of which is a drift scale showing from 0° to 30° Port and Starboard drift. The wind arm is graduated in Wind Speed ratios and has a WIND DIRN line on one end to enable the wind direction to be set up against the outer compass rose.

TO CONVERT SPEEDS (s) INTO RATIOS (r)
OF TAS & VICE VERSA

Use the circular slide rule side of the CRP-9 for these conversions.

Set 1 on the inner scale opposite TAS on the outer scale (use 10 as 1.0)

Example: **Convert 2650km to n.m. and st.m.**
Rough Check: 2600 ÷ 2 = 1300n.m. = 1560 st.m.

<u>*Set slide rule*</u>

Align 2650 on the inner scale with the red **km** datum (at 10 on the outer scale). Put the cursor through the red **naut.m.** datum (near 54 on the outer scale) and read off 1430nm on the inner scale, then put the cursor through the red **stat.m.** datum (near 62 on the outer scale) and read off 1640 stat.m on the inner scale. The rough checks having ensured that the final answers must be in the region of 1500.

CONVERSION BETWEEN KNOTS, MPH AND KPH

Since knots (kt) are nautical miles per hour, mph are statute miles per hour and kph are kilometres per hour the same datums and rough conversion factors are used as for the distance conversion.

Example: **Convert 363kt to mph and kph**
Rough Check: 360kt = 432 mph = 720 kph

<u>*Set slide rule*</u>

Align 363 on the inner scale with the red **naut.m** datum. Put the cursor through the red **stat.m.** datum and read of 419 mph on the inner scale, then put the cursor through the red **km** datum an read off 673 kph on the inner scale.

CONVERSION BETWEEN IMPERIAL GALLONS, US GALLONS AND LITRES

The rough conversion factors for checking purposes are 1 Imp gal = 1.2 US gal = 4.5 ltr.

Example: **Convert 25200ltr to Imp gal and US gal**
Rough Check: 25000 ltr = 5500 Imp gal = 6600 US gal

Example: **Calculate the head and cross wind components on RW19 if the ATC surface WV is 150/25.**

Note: *RW directions are to the nearest 10°(M) and ATC surface WV is always given in °(M). They do not need converting into °(T) to solve for the wind components on the RW.*

Note: TAF and METAR W/V are in True; ATC and ATIS W/V are magnetic

Position the top line of the squared section through the centre dot. Align wind direction 150°(M) with the index mark and pencil in the wind cross on the centre line 25 units **BELOW** the centre dot using the squared scale. Rotate the window disc to align 190°(M) (RW19) with the index mark, this will displace the wind cross to the right of the centre line. Read off the head wind component of 20 kts vertically down from the top line to the wind cross. Read off the cross wind component of 17 kts horizontally **FROM** the centre line **TO** the wind cross, ie., from Port (left) to Starboard (right).

Answer: **Head wind component 20 kts, cross wind component 17 kts from left to right.**

Note: If having set on the surface WV and a RW direction the wind cross position is above the top line the RW in question would have a tail wind, try the reciprocal of the RW to get a head wind component. The best RW to use is the one nearest into the surface WV as this will have the best head wind and least cross wind. Take-off or landing should NEVER be attempted on any RW giving a crosswind component greater than the maximum crosswind limitation for the aircraft type being flown.

Example: **Convert 708 Imp gal of fuel (Sp.G 0.74) into US gal, ltr, kgs and lbs.**

Rough Check: 700 Imp gal x 1.2 =840 Us gal = 3150ltr x Sp.G r 0.75 = 2400kg x 2.2 = 5280lbs

Set slide rule

Align 708 on the inner scale with the red **Imp gal** datum on the outer scale. Using the cursor as for volume conversions read off from their datums 850 US gal and 3215ltr. Now put the cursor through 0.74 on the **Sp.G** scale to the left of the ltrs datum (use the 74 below the **Sp.G** scale) and read off 2380kgs on the inner scale. Reposition the cursor through the 0.74 on the other Sp.G and read off 5250lbs on the inner scale.

Using these scale, if Sp.G and weight are known then volumes can be found and if a weight and volume are known the Sp.G can be found.

CONVERSION OF TEMPERATURES BETWEEN °F AND °C

There is a straightforward conversion scale at the bottom of this side of the computer, just read from one scale to the other.

That concludes the section the conversions that are programmed into the computer. A return to the use of ratios in the solution of other aviation problems now follows.

SPEED, DISTANCE AND TIME PROBLEMS

Speed is distance travelled in 60 minutes and this can be expressed as the ratio.

$$\frac{\text{SPEED (Dist in 60 min)}}{60 \ (\text{min})} = \frac{\text{DISTANCE}}{\text{TIME (min)}}$$

The computer is now set up with TAS under the centre dot, the wind vector blowing from the centre dot with its wind cross over the intersection of drift line and GS speed arc, the required Trk opposite the same value of drift on the fixed scale and the Hdg to steer under the index mark.

Read off Hdg to steer 045°(T) under the index mark and the GS 144 kts on the speed arc through the wind cross.

Answer: **Hdg to steer 045°(T) and GS 144 kts.**

TO CHECK WV AT A TURNING POINT

Various means of finding drift exist and if by any of these methods drift is checked when inbound to, and outbound from, a turning point it is possible to check the WV, provided the change of heading is large. Inbound Hdg and drift, Outbound Hdg and drift plus TAS are the only requirements to solve for WV.

Set speed arc of TAS through centre dot. With Inbound Hdg aligned with the index mark draw a pencil line on the window down the Inbound drift line on the scale. Rotate the window disc to align the Outbound Hdg with the index mark and draw a pencil line on the window down the Outbound drift line to cut the first pencil line. Where the two lines intersect is the wind cross. Rotate the window disc to position the wind cross on the centre line **BELOW** the centre dot. Read off wind direction under the index mark. Read off the length of the vector from the centre dot to the wind cross to find the wind speed.

Example: **TAS 220 kts; Inbound Hdg 195°(T); Inbound drift 6° Starboard; Outbound Hdg 278°(T); Outbound drift 4° Port.**

TO CALCULATE DISTANCE

Example: **An aircraft has a GS of 354 kt. How many nm will it cover in 94 mins?**

Rough Check: 94 mins is just over $1\frac{1}{2}$ hour, therefore distance covered will be just over $1\frac{1}{2}$ x GS, say $1\frac{1}{2}$ x 360 = 540 nm.

Set slide rule

Align the 60 datum mark on the inner scale with the GS of 354 kt on the outer scale. Position the cursor through the time of 94 min on the inner scale and read off the distance of 554 nm on the outer scale.

Note: *If using speed in mph then distances will be in stat.m and if using speed in kph then distances will be in km.*

FUEL CONSUMPTION, FUEL AND TIME

Problems involving fuel are solved in a similar way to the Speed, Distance and Time problems. For fuel problems the ratio is:

$$\frac{\text{FUEL CONSUMPTION (or flow)}}{\boxed{60} \text{ (min)}} =$$

$$\frac{\text{FUEL (available or used)}}{\text{TIME (min)}}$$

Fuel quantities can be quoted in any of the volume or weight units already described in the conversion section. Take care not to mix units within a calculation.

SOLVING FROM HEADING (Hdg) & GROUND SPEED (GS) knowing WV, TAS and required Trk.

Check for maximum and minimum possible GS and select the appropriate side of the speed slide (**L** or **H**) to use.

Mark on the WV as previously described, putting the wind cross **BELOW** the centre dot.

Move the slide to position the TAS speed arc through the centre dot.

To set about finding the Hdg to steer first align the desired Trk direction on the window disc with the index mark on the fixed scale (treating the index as zero drift) and read off the drift from the drift line passing through the wind cross.

If the drift so found is zero (matching the zero drift opposite the Trk direction) then the Hdg to steer will be the same as the required Trk direction and all that has to be done to complete the solution is to read off the GS from the speed arc passing through the wind cross.

It is more likely that the wind cross will be off to one side of the centre line, lying over one of the angled drift line on the slide. If so, read off this value of drift and rotate the window disc to align the required Trk direction with the identical value of drift on the fixed scale. In so doing the wind cross may shift its position to lie over a different drift line, in which case reposition the required Trk direction to lie under this new value of drift on the fixed scale. Keep adjusting the position of the required Trk direction until the drift opposite it on the fixed scale is the same as the drift line under the wind cross. In practice this adjustment only takes seconds to do.

The computer is now set up ready for reading off Hdg and GS.

Read off Hdg to steer on the window disc opposite the index mark on the fixed scale. Read off GS from the speed arc passing through the wind cross.

510 US gal/hr on the outer scale. Position the cursor through the fuel available of 3260 US Gal on the outer scale and read off the endurance of 384 min on the inner scale.

CALCULATION OF
TRUE AIRSPEED (TAS)

The Airspeed Indicator (ASI) measures the difference between Pitot and Static pressures, this difference being the dynamic pressure due to the forward motion of the aircraft. Dynamic pressure is generated by the number of air molecules that collide with the airframe as it moves forward and is therefore a function of both air density and TAS.

The ASI is calibrated to indicate speed on the assumption that air density has a fixed value of 1225 grammes/cubic metre (msl International Standard Atmosphere density). Since actual air density varies with altitude and temperature a correction, called density error correction, is necessary if TAS is to be calculated.

The Indicated Airspeed (IAS) showing on the ASI has first to be corrected for any instrument and position errors, the correction normally being found on a calibration card placed near the ASI. The corrected speed is known as the Rectified Airspeed (RAS) or now more usually Calibrated Air Speed (CAS) and is used in conjunction with pressure altitude and corrected outside air temperature (COAT)(often referred to as Static Air Temperature - SAT) to solve for TAS on the computer.

Example: **Hdg. 116°(T); TAS 120kts and WV 260°
                (T)/40 kts. Find Trk°(T) and GS kts.**

Maximum   GS = 120 + 40 = 160 kts, minimum
GS = 120 - 40 = 80 kts, therefore use **L** side of slide.

Mark on the wind cross, with 260° under the index mark pencil
cross 40 speed units BELOW the centre dot. Move the slide to
position the 120 (TAS) speed arc through the centre dot. Rotate
window disc to align. Hdg 116°(T) under the index mark.

**The computer is now set up with TAS under the centre dot,
Hdg aligned with the index mark and WV blowing out from the
centre dot.**

Under the wind cross read off drift 9° Port and GS 154 kts.
From 9° Port on the fixed scale read in to find Trk 107°(T) on the
window disc.

Answer: **Trk 107°(T) GS 154 kts**

SOLVING FOR WIND VELOCITY (WV)

Knowing Hdg. and TAS plus Trk and GS.

Select the side of slide (**L** or **H**) that will accommodate both TAS
and GS. Move the slide to position the TAS speed arc through the
centre dot. Align the Hdg direction on the window disc with the index
mark on the fixed scale.

**The computer is now set up ready for marking on the wind
cross to find the WV.**

Read from Trk direction on the window disc outwards to find
drift on the fixed scale.

CALCULATION OF RAS TO TAS (Over 300 kt)

Having calculated RAS to TAS, as previously described, if the TAS comes out at over 300 kt proceed as follows. Note the value of this initial TAS and apply it in the formula to be found by the **Comp.Corr.** window, ie TAS/100 -3 Div. The answer this gives is the number of divisions that the arrow pointing at the Comp.Corr. window has to be moved to the left against the scale visible in the window. This scale varies and has large spacing at high altitude and very close spacing at low altitudes; in fact at msl it is at infinity α. Moving the pointer to the left will reposition the RAS opposite a lower value TAS which is the correct TAS to use.

> *Example:* **Pressure altitude 35000 ft, COAT -47°C, RAS 280 kt, what is the TAS?**

In **Air Speed** window set 35 (pressure altitude x 1000ft) opposite -47°C on the COAT scale. Position the cursor through the RAS of 280 kt on the inner slide rule scale and read off the initial TAS of 500 kt on the outer scale. Since this is over 300 kt enter the 500 kt initial TAS into the formula giving 500/100 -3 = 2 Div. The arrow is pointing just to the left of 38 on the scale in the **Comp. Corr.** window (numbers increase to left on this scale) so move the inner disc to position the arrow 2 divisions to the left, just beyond 40. Reposition the cursor through the RAS of 280 kt on the inner scale and read off the correct TAS of 480 kt on the outer scale.

Note: *The expression Equivalent Airspeed (EAS) may be encountered from time to time; this is RAS corrected for compressibility error only. EAS is used in design work and test flying; it is not normally used in every day flying.*

Note: *The direction of <u>Hdg</u> and <u>Trk</u> is that towards which the movement is being made, whereas the direction of the <u>Wind</u> is always that from with the wind is blowing.*

In navigation the main problems regarding these velocities are:

1.   Solving for Trk and GS when Hdg and TAS plus WV are known.

2.   Solving for WV when Hdg and TAS plus Trk and GS are known.

3.   Solving for Hdg to steer and expected GS when TAS, WV and desired Trk are known.

These problems are most easily solved by drawing a triangle of velocities to a common vector scale and direction datum. The rotatable window and slide enable the triangle to be solved with a minimum of drawing. In the examples that follow speeds will be given in kts and directions in °(T). The methods are those employed in Commercial aviation and, as will be seen, the way the various components are set up is identical in every case.

TO SET ON A WIND VELOCITY (WV)

Align wind direction on the window disc with the index mark on the fixed scale and, using a soft pencil, mark a cross on the centre line **BELOW** the centre dot at a distance from the centre dot equal to the wind speed. Use the spacing on the slide to find the cross position.

> *Example:*   **Set WV 210°/30 on the window disc using the Low speed L side of the slide.**

Align wind direction 210° on the window disc with the index mark on the fixed scale. Move the **L** slide to position, say, the 130 speed arc through the centre dot and mark a cross **BELOW** the centre dot where the 100 speed are crosses the centre line.

TEMPERATURE RISE SCALE

This scale is for use by pilots who prefer to use the temperature shown on the indicated temperature gauge in the aircraft rather than the meteorological forecast temperatures. Except at very low speeds the indicated temperature is always higher than COAT due to kinetic heating on the temperature probe. Kinetic heating is a function of TAS and the scale gives the amount of over indication of temperature at different TAS's. The value found should be subtracted from indicated temperature to give COAT. The method is to compute for RAS to TAS using indicated temperature to get an approximate TAS, use this TAS to find the temperature to get an approximate TAS, use this TAS to find the temperature rise on the scale and use this to amend the indicated temperature to compute COAT. Finally recompute RAS to TAS using the newly computed COAT to get the correct TAS.

> *Example:*   **Indicated temperature -30°C , pressure altitude 25000 ft, RAS 200 kts. What is TAS?**

In **Air Speed** window align 25 (pressure altitude x 1000 feet) with indicated temperatures -30°C on the COAT scale. Position cursor through RAS of 200 kts on the inner circular slide rule scale and read off approximate TAS of 297 kts on the outer scale. Enter **Temp Rise** scale with this TAS and pick off temperature rise of 9°C and subtract it from the indicated temperature, -30°C -9°C = COAT -39°C. Recomputing RAS to TAS using -39°C will give a correct TAS of 292 kts.

Note: If your first (approximate) TAS comes to more than 300 kts, compressibility correction must be applied, even on the first rough TAS to find the Temperature Rise. It must then be applied again in the accurate TAS, if above 300 knots.

Example: **Heading 075° (T), drift 11° Port.**
What is the Track °(T)?

Align. Heading 075°(T), on the window disc with the index mark. Reading from 11° Port drift on the fixed scale find Track 064° (T) on the window disc.

Example: **Heading 227° (T), results in a Track of 241° (T)**
What is the Drift?

Align. Heading 227°(T), on the window disc with the index mark. Reading from Track 241°(T) on the window disc find drift of 14° Starboard on the fixed scale.

APPLICATION OF VARIATION

Aligning a known Heading °(T) with the index mark enables the Heading °(M) to be read off the window disc opposite the local variation of the fixed scale. Similarly if Heading °(M) is aligned with the local variation then Heading °(T) will be found under the index mark.

Example: **Heading 217° (T), variation 21° East.**
What is the Heading °(M)?

Align. Heading 217°(T), on the window disc with the index mark. Reading from 21°East on the fixed variation scale find Heading 196°(M) on the window disc.

Example: **Heading 005° (M), variation 8° West.**
What is the Heading °(T)?

Align. Heading 005°(M), with 8°West on the fixed variation scale. Read of Heading 357°(T) on the window disc opposite the index mark.

Example: **At 0 feet (msl) the ISA temperature is +15°C and at 20,000 feet it is -25°C.**

Note: *The altitudes on the <u>Altitude</u> window are labelled Pressure Altitude, that is to say altitude measured from the standard pressure datum of 1013 millibars.*

The inner slide rule scale now represents the Indicated Altitude measured from the local QNH (mean sea level pressure) setting and the outer slide rule scale now gives the corresponding True Altitude. It follows that if the ambient temperature structure is identical to the ISA then the True Altitude will be the same as the Indicated Altitude. The setting put on as an example illustrates this situation.

However if the temperature at 20,000 feet were colder than the ISA temperature, say -35°C, lining up 20,000 feet Pressure Altitude opposite -35°C in the **Altitude** window will move the inner slide rule scale anti-clockwise and now opposite 20,000 feet Indicated Altitude on the inner scale (Assuming QNH = 1013 millibars) on the outer scale the True Altitude is seen to be 19,200 feet. Similarly a warmer than ISA temperature of -10°C at 20,000 feet will give a True Altitude of 21200 feet for an Indicated Altitude of 20,000 feet.

In these examples the Altimeter is sensing the same pressure and giving the same Indicated Altitude. In the colder than ISA situation the True Altitude is lower than Indicated Altitude and in the warmer than ISA situation it is higher than Indicated Altitude. The cause of this is the temperature effect on air density. In the colder air the density increases as the air contracts and packs more weight of air into a given volume, whereas warmer air becomes less dense as it expands. In the colder, more dense, air the rate of fall of pressure with altitude is faster than in the ISA and in the warmer, less dense, air the rate of fall of pressure with altitude is slower.

Rotate the inner disc of the computer to align the airfield elevation (using the Press Alt x 1000 ft scale) inside the **Air Speed** window with the airfield surface temperature (using the COAT outer scale of the **Air Speed** window). Go the **Density Altitude** window and opposite the arrow read of the **Density Altitude** inside the window.

> *For Example:* **Airfield elevation 5000 feet amsl,**
> **surface temperature +5°C.**
> **What is the Density Altitude?**

Set 5000 feet in the **Air Speed** window opposite +5°C (just to the left of 0) on the COAT scale. Opposite the arrow on the Density Altitude window read off the **Density Altitude** of 5000 feet. In this case airfield elevation and **Density Altitude** are the same because +5°C happens to be the temperature at 5000 feet in the ISA.

Now try the same airfield on a really hot day with the surface temperature of +30°C. What is the **Density Altitude** now?

Set 5000 feet in the **Air Speed** window opposite + 30°C (remember + is to the left of 0) on the COAT scale. Opposite the arrow on the **Density Altitude** window read off the **Density Altitude** of 8000 feet.

Remember the hotter and higher the airfield, the poorer the aircraft will perform, and some payload may have to be shed to ensure safe operation of the aircraft.

Rotate the inner disc of the computer to align the airfield elevation (using the Press Alt x 1000 ft scale) inside the **Air Speed** window with the airfield surface temperature (using the COAT outer scale of the **Air Speed** window). Go the **Density Altitude** window and opposite the arrow read of the **Density Altitude** inside the window.

> ### *For Example:*   **Airfield elevation 5000 feet amsl,**
> **surface temperature +5°C.**
> **What is the Density Altitude?**

Set 5000 feet in the **Air Speed** window opposite +5°C (just to the left of 0) on the COAT scale. Opposite the arrow on the Density Altitude window read off the **Density Altitude** of 5000 feet. In this case airfield elevation and **Density Altitude** are the same because +5°C happens to be the temperature at 5000 feet in the ISA.

Now try the same airfield on a really hot day with the surface temperature of +30°C. What is the **Density Altitude** now?

Set 5000 feet in the **Air Speed** window opposite + 30°C (remember + is to the left of 0) on the COAT scale. Opposite the arrow on the **Density Altitude** window read off the **Density Altitude** of 8000 feet.

Remember the hotter and higher the airfield, the poorer the aircraft will perform, and some payload may have to be shed to ensure safe operation of the aircraft.

Example: **At 0 feet (msl) the ISA temperature is +15°C and at 20,000 feet it is -25°C.**

Note: *The altitudes on the <u>Altitude</u> window are labelled Pressure Altitude, that is to say altitude measured from the standard pressure datum of 1013 millibars.*

The inner slide rule scale now represents the Indicated Altitude measured from the local QNH (mean sea level pressure) setting and the outer slide rule scale now gives the corresponding True Altitude. It follows that if the ambient temperature structure is identical to the ISA then the True Altitude will be the same as the Indicated Altitude. The setting put on as an example illustrates this situation.

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In these examples the Altimeter is sensing the same pressure and giving the same Indicated Altitude. In the colder than ISA situation the True Altitude is lower than Indicated Altitude and in the warmer than ISA situation it is higher than Indicated Altitude. The cause of this is the temperature effect on air density. In the colder air the density increases as the air contracts and packs more weight of air into a given volume, whereas warmer air becomes less dense as it expands. In the colder, more dense, air the rate of fall of pressure with altitude is faster than in the ISA and in the warmer, less dense, air the rate of fall of pressure with altitude is slower.

Example: **Heading 075° (T), drift 11° Port.**
What is the Track °(T)?

Align. Heading 075°(T), on the window disc with the index mark. Reading from 11° Port drift on the fixed scale find Track 064° (T) on the window disc.

Example: **Heading 227° (T), results in a Track of 241° (T)**
What is the Drift?

Align. Heading 227°(T), on the window disc with the index mark. Reading from Track 241°(T) on the window disc find drift of 14° Starboard on the fixed scale.

APPLICATION OF VARIATION

Aligning a known Heading °(T) with the index mark enables the Heading °(M) to be read off the window disc opposite the local variation of the fixed scale. Similarly if Heading °(M) is aligned with the local variation then Heading °(T) will be found under the index mark.

Example: **Heading 217° (T), variation 21° East.**
What is the Heading °(M)?

Align. Heading 217°(T), on the window disc with the index mark. Reading from 21°East on the fixed variation scale find Heading 196°(M) on the window disc.

Example: **Heading 005° (M), variation 8° West.**
What is the Heading °(T)?

Align. Heading 005°(M), with 8°West on the fixed variation scale. Read of Heading 357°(T) on the window disc opposite the index mark.

TEMPERATURE RISE SCALE

This scale is for use by pilots who prefer to use the temperature shown on the indicated temperature gauge in the aircraft rather than the meteorological forecast temperatures. Except at very low speeds the indicated temperature is always higher than COAT due to kinetic heating on the temperature probe. Kinetic heating is a function of TAS and the scale gives the amount of over indication of temperature at different TAS's. The value found should be subtracted from indicated temperature to give COAT. The method is to compute for RAS to TAS using indicated temperature to get an approximate TAS, use this TAS to find the temperature to get an approximate TAS, use this TAS to find the temperature rise on the scale and use this to amend the indicated temperature to compute COAT. Finally recompute RAS to TAS using the newly computed COAT to get the correct TAS.

> *Example:*   **Indicated temperature -30°C , pressure altitude 25000 ft, RAS 200 kts. What is TAS?**

In **Air Speed** window align 25 (pressure altitude x 1000 feet) with indicated temperatures -30°C on the COAT scale. Position cursor through RAS of 200 kts on the inner circular slide rule scale and read off approximate TAS of 297 kts on the outer scale. Enter **Temp Rise** scale with this TAS and pick off temperature rise of 9°C and subtract it from the indicated temperature, -30°C -9°C = COAT -39°C. Recomputing RAS to TAS using -39°C will give a correct TAS of 292 kts.

Note: If your first (approximate) TAS comes to more than 300 kts, compressibility correction must be applied, even on the first rough TAS to find the Temperature Rise. It must then be applied again in the accurate TAS, if above 300 knots.

Note: *The direction of <u>Hdg</u> and <u>Trk</u> is that towards which the movement is being made, whereas the direction of the <u>Wind</u> is always that from with the wind is blowing.*

In navigation the main problems regarding these velocities are:

1. Solving for Trk and GS when Hdg and TAS plus WV are known.

2. Solving for WV when Hdg and TAS plus Trk and GS are known.

3. Solving for Hdg to steer and expected GS when TAS, WV and desired Trk are known.

These problems are most easily solved by drawing a triangle of velocities to a common vector scale and direction datum. The rotatable window and slide enable the triangle to be solved with a minimum of drawing. In the examples that follow speeds will be given in kts and directions in °(T). The methods are those employed in Commercial aviation and, as will be seen, the way the various components are set up is identical in every case.

TO SET ON A WIND VELOCITY (WV)

Align wind direction on the window disc with the index mark on the fixed scale and, using a soft pencil, mark a cross on the centre line **BELOW** the centre dot at a distance from the centre dot equal to the wind speed. Use the spacing on the slide to find the cross position.

> *Example:* **Set WV 210°/30 on the window disc using the Low speed L side of the slide.**

Align wind direction 210° on the window disc with the index mark on the fixed scale. Move the **L** slide to position, say, the 130 speed arc through the centre dot and mark a cross **BELOW** the centre dot where the 100 speed are crosses the centre line.

CALCULATION OF RAS TO TAS (Over 300 kt)

Having calculated RAS to TAS, as previously described, if the TAS comes out at over 300 kt proceed as follows. Note the value of this initial TAS and apply it in the formula to be found by the **Comp.Corr.** window, ie TAS/100 -3 Div. The answer this gives is the number of divisions that the arrow pointing at the Comp.Corr. window has to be moved to the left against the scale visible in the window. This scale varies and has large spacing at high altitude and very close spacing at low altitudes; in fact at msl it is at infinity α. Moving the pointer to the left will reposition the RAS opposite a lower value TAS which is the correct TAS to use.

> *Example:* **Pressure altitude 35000 ft, COAT -47°C, RAS 280 kt, what is the TAS?**

In **Air Speed** window set 35 (pressure altitude x 1000ft) opposite -47°C on the COAT scale. Position the cursor through the RAS of 280 kt on the inner slide rule scale and read off the initial TAS of 500 kt on the outer scale. Since this is over 300 kt enter the 500 kt initial TAS into the formula giving 500/100 -3 = 2 Div. The arrow is pointing just to the left of 38 on the scale in the **Comp. Corr.** window (numbers increase to left on this scale) so move the inner disc to position the arrow 2 divisions to the left, just beyond 40. Reposition the cursor through the RAS of 280 kt on the inner scale and read off the correct TAS of 480 kt on the outer scale.

Note: *The expression Equivalent Airspeed (EAS) may be encountered from time to time; this is RAS corrected for compressibility error only. EAS is used in design work and test flying; it is not normally used in every day flying.*

Example: **Hdg. 116°(T); TAS 120kts and WV 260° (T)/40 kts. Find Trk°(T) and GS kts.**

Maximum GS = 120 + 40 = 160 kts, minimum GS = 120 - 40 = 80 kts, therefore use **L** side of slide.

Mark on the wind cross, with 260° under the index mark pencil cross 40 speed units BELOW the centre dot. Move the slide to position the 120 (TAS) speed arc through the centre dot. Rotate window disc to align. Hdg 116°(T) under the index mark.

The computer is now set up with TAS under the centre dot, Hdg aligned with the index mark and WV blowing out from the centre dot.

Under the wind cross read off drift 9° Port and GS 154 kts. From 9° Port on the fixed scale read in to find Trk 107°(T) on the window disc.

Answer: **Trk 107°(T) GS 154 kts**

SOLVING FOR WIND VELOCITY (WV)

Knowing Hdg. and TAS plus Trk and GS.

Select the side of slide (**L** or **H**) that will accommodate both TAS and GS. Move the slide to position the TAS speed arc through the centre dot. Align the Hdg direction on the window disc with the index mark on the fixed scale.

The computer is now set up ready for marking on the wind cross to find the WV.

Read from Trk direction on the window disc outwards to find drift on the fixed scale.

510 US gal/hr on the outer scale. Position the cursor through the fuel available of 3260 US Gal on the outer scale and read off the endurance of 384 min on the inner scale.

CALCULATION OF TRUE AIRSPEED (TAS)

The Airspeed Indicator (ASI) measures the difference between Pitot and Static pressures, this difference being the dynamic pressure due to the forward motion of the aircraft. Dynamic pressure is generated by the number of air molecules that collide with the airframe as it moves forward and is therefore a function of both air density and TAS.

The ASI is calibrated to indicate speed on the assumption that air density has a fixed value of 1225 grammes/cubic metre (msl International Standard Atmosphere density). Since actual air density varies with altitude and temperature a correction, called density error correction, is necessary if TAS is to be calculated.

The Indicated Airspeed (IAS) showing on the ASI has first to be corrected for any instrument and position errors, the correction normally being found on a calibration card placed near the ASI. The corrected speed is known as the Rectified Airspeed (RAS) or now more usually Calibrated Air Speed (CAS) and is used in conjunction with pressure altitude and corrected outside air temperature (COAT)(often referred to as Static Air Temperature - SAT) to solve for TAS on the computer.

SOLVING FROM HEADING (Hdg) & GROUND SPEED (GS) knowing WV, TAS and required Trk.

Check for maximum and minimum possible GS and select the appropriate side of the speed slide (**L** or **H**) to use.

Mark on the WV as previously described, putting the wind cross **BELOW** the centre dot.

Move the slide to position the TAS speed arc through the centre dot.

To set about finding the Hdg to steer first align the desired Trk direction on the window disc with the index mark on the fixed scale (treating the index as zero drift) and read off the drift from the drift line passing through the wind cross.

If the drift so found is zero (matching the zero drift opposite the Trk direction) then the Hdg to steer will be the same as the required Trk direction and all that has to be done to complete the solution is to read off the GS from the speed arc passing through the wind cross.

It is more likely that the wind cross will be off to one side of the centre line, lying over one of the angled drift line on the slide. If so, read off this value of drift and rotate the window disc to align the required Trk direction with the identical value of drift on the fixed scale. In so doing the wind cross may shift its position to lie over a different drift line, in which case reposition the required Trk direction to lie under this new value of drift on the fixed scale. Keep adjusting the position of the required Trk direction until the drift opposite it on the fixed scale is the same as the drift line under the wind cross. In practice this adjustment only takes seconds to do.

The computer is now set up ready for reading off Hdg and GS.

Read off Hdg to steer on the window disc opposite the index mark on the fixed scale. Read off GS from the speed arc passing through the wind cross.

TO CALCULATE DISTANCE

Example: **An aircraft has a GS of 354 kt. How many nm will it cover in 94 mins?**

Rough Check: 94 mins is just over $1\frac{1}{2}$ hour, therefore distance covered will be just over $1\frac{1}{2}$ x GS, say $1\frac{1}{2}$ x 360 = 540 nm.

Set slide rule

Align the 60 datum mark on the inner scale with the GS of 354 kt on the outer scale. Position the cursor through the time of 94 min on the inner scale and read off the distance of 554 nm on the outer scale.

Note: *If using speed in mph then distances will be in stat.m and if using speed in kph then distances will be in km.*

FUEL CONSUMPTION, FUEL AND TIME

Problems involving fuel are solved in a similar way to the Speed, Distance and Time problems. For fuel problems the ratio is:

$$\frac{\text{FUEL CONSUMPTION (or flow)}}{\cancel{60} \text{ (min)}} \quad = $$

$$\frac{\text{FUEL (available or used)}}{\text{TIME (min)}}$$

Fuel quantities can be quoted in any of the volume or weight units already described in the conversion section. Take care not to mix units within a calculation.

The computer is now set up with TAS under the centre dot, the wind vector blowing from the centre dot with its wind cross over the intersection of drift line and GS speed arc, the required Trk opposite the same value of drift on the fixed scale and the Hdg to steer under the index mark.

Read off Hdg to steer 045°(T) under the index mark and the GS 144 kts on the speed arc through the wind cross.

Answer: **Hdg to steer 045°(T) and GS 144 kts.**

TO CHECK WV AT A TURNING POINT

Various means of finding drift exist and if by any of these methods drift is checked when inbound to, and outbound from, a turning point it is possible to check the WV, provided the change of heading is large. Inbound Hdg and drift, Outbound Hdg and drift plus TAS are the only requirements to solve for WV.

Set speed arc of TAS through centre dot. With Inbound Hdg aligned with the index mark draw a pencil line on the window down the Inbound drift line on the scale. Rotate the window disc to align the Outbound Hdg with the index mark and draw a pencil line on the window down the Outbound drift line to cut the first pencil line. Where the two lines intersect is the wind cross. Rotate the window disc to position the wind cross on the centre line **BELOW** the centre dot. Read off wind direction under the index mark. Read off the length of the vector from the centre dot to the wind cross to find the wind speed.

Example: **TAS 220 kts; Inbound Hdg 195°(T); Inbound drift 6° Starboard; Outbound Hdg 278°(T); Outbound drift 4° Port.**

> *Example:* **Convert 708 Imp gal of fuel (Sp.G 0.74) into**
> **US gal, ltr, kgs and lbs.**
> *Rough Check:* 700 Imp gal x 1.2 =840 Us gal = 3150ltr x Sp.G
> r 0.75 = 2400kg x 2.2 = 5280lbs

Set slide rule

Align 708 on the inner scale with the red **Imp gal** datum on the outer scale. Using the cursor as for volume conversions read off from their datums 850 US gal and 3215ltr. Now put the cursor through 0.74 on the **Sp.G** scale to the left of the ltrs datum (use the 74 below the **Sp.G** scale) and read off 2380kgs on the inner scale. Reposition the cursor through the 0.74 on the other Sp.G and read off 5250lbs on the inner scale.

Using these scale, if Sp.G and weight are known then volumes can be found and if a weight and volume are known the Sp.G can be found.

CONVERSION OF TEMPERATURES BETWEEN °F AND °C

There is a straightforward conversion scale at the bottom of this side of the computer, just read from one scale to the other.

That concludes the section the conversions that are programmed into the computer. A return to the use of ratios in the solution of other aviation problems now follows.

SPEED, DISTANCE AND TIME PROBLEMS

Speed is distance travelled in 60 minutes and this can be expressed as the ratio.

$$\frac{\text{SPEED (Dist in 60 min)}}{\cancel{60} \text{ (min)}} = \frac{\text{DISTANCE}}{\text{TIME (min)}}$$

Example: **Calculate the head and cross wind components on RW19 if the ATC surface WV is 150/25.**

Note: *RW directions are to the nearest 10°(M) and ATC surface WV is always given in °(M). They do not need converting into °(T) to solve for the wind components on the RW.*

Note: TAF and METAR W/V are in True; ATC and ATIS W/V are magnetic

Position the top line of the squared section through the centre dot. Align wind direction 150°(M) with the index mark and pencil in the wind cross on the centre line 25 units **BELOW** the centre dot using the squared scale. Rotate the window disc to align 190°(M) (RW19) with the index mark, this will displace the wind cross to the right of the centre line. Read off the head wind component of 20 kts vertically down from the top line to the wind cross. Read off the cross wind component of 17 kts horizontally **FROM** the centre line **TO** the wind cross, ie., from Port (left) to Starboard (right).

Answer: **Head wind component 20 kts, cross wind component 17 kts from left to right.**

Note: If having set on the surface WV and a RW direction the wind cross position is above the top line the RW in question would have a tail wind, try the reciprocal of the RW to get a head wind component. The best RW to use is the one nearest into the surface WV as this will have the best head wind and least cross wind. Take-off or landing should NEVER be attempted on any RW giving a crosswind component greater than the maximum crosswind limitation for the aircraft type being flown.

Example: **Convert 2650km to n.m. and st.m.**
Rough Check: 2600 ÷ 2 = 1300n.m. = 1560 st.m.

Set slide rule

Align 2650 on the inner scale with the red **km** datum (at 10 on the outer scale). Put the cursor through the red **naut.m.** datum (near 54 on the outer scale) and read off 1430nm on the inner scale, then put the cursor through the red **stat.m.** datum (near 62 on the outer scale) and read off 1640 stat.m on the inner scale. The rough checks having ensured that the final answers must be in the region of 1500.

CONVERSION BETWEEN KNOTS, MPH AND KPH

Since knots (kt) are nautical miles per hour, mph are statute miles per hour and kph are kilometres per hour the same datums and rough conversion factors are used as for the distance conversion.

Example: **Convert 363kt to mph and kph**
Rough Check: 360kt = 432 mph = 720 kph

Set slide rule

Align 363 on the inner scale with the red **naut.m** datum. Put the cursor through the red **stat.m.** datum and read of 419 mph on the inner scale, then put the cursor through the red **km** datum an read off 673 kph on the inner scale.

CONVERSION BETWEEN IMPERIAL GALLONS, US GALLONS AND LITRES

The rough conversion factors for checking purposes are 1 Imp gal = 1.2 US gal = 4.5 ltr.

Example: **Convert 25200ltr to Imp gal and US gal**
Rough Check: 25000 ltr = 5500 Imp gal = 6600 US gal

matching scale arm.

SOLVING FOR WIND VELOCITY (WV)
knowing Hdg and TAS plus Trk and GS

Proceed exactly as for the CRP-5 except that instead of marking the wind cross at the intersection of the drift and GS, the arm of the wind bar whose scale matches the slide scale, is rotated to pass through the point of intersection. Read off the wind direction on the window disc opposite the other arm of the wind bar and read off wind speed on the matching scale arm at the point of intersection of the drift and GS.

Try reworking the example given for the CRP-5 by this method.

CRP-9; WIND TRIANGLE PROBLEMS

The reverse side of the CRP-9 computer is arranged to solve the navigational triangle of velocities without the use of a slide. The principle is based upon 'similar triangles', the TAS being taken as unity (factor of 1) and the Wind and Ground Speeds are expressed as ratios of the TAS.

The large outer disc has compass rose around its edge. The smaller centre disc is grided in drift lines and GS ratios, at the top it has a HEADING INDEX either side of which is a drift scale showing from 0° to 30° Port and Starboard drift. The wind arm is graduated in Wind Speed ratios and has a WIND DIRN line on one end to enable the wind direction to be set up against the outer compass rose.
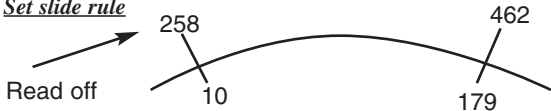
TO CONVERT SPEEDS (s) INTO RATIOS (r)
OF TAS & VICE VERSA

Use the circular slide rule side of the CRP-9 for these conversions.

Set 1 on the inner scale opposite TAS on the outer scale (use 10 as 1.0)

Example: **462 ÷ 17.9.**
Rough Check   say, 500 ÷ 20 = 25

<u>*Set slide rule*</u>

Rough answer 25, therefore actual answer 25.8 (and not 258).

MULTIPLICATION

A multiplied by B can be written as A/1 = Answer/B.
On the circular slide rule this is set thus

Example: **0.015 x 0.26.**
Rough Check: Say, 0.02 x 0.2 = 0.004

<u>*Set slide rule*</u>

Rough answer 0.004, therefore actual answer 0.0039 (and not 0.039 or 0.00039).

In both division and multiplication the 10 (used as 1.0) played a key role as a constant. Because of its frequent use as a constant it has been highlighted in blue on both the inner and outer scales.

Convert the GS ratio into a GS.

Example: **Hdg (T) 265, WV 210/35, TAS 290 kts.**
              What is Trk and GS?

Calculate WV ratio.

Rough Check: 30 divided by 300 = 0.1

Set 1 on the inner scale against 290 on the outer scale, against 35 on the outer scale read off WV Ratio 0.12 on the inner scale.

Rotate the wind arm until **WIND DIRN** line lies over 210° on the outer compass rose.

Holding wind arm in place rotate grided disc until HEADING INDEX points to 265° on outer compass rose.

Under the WV ratio on the wind arm read off drift 6° Starboard and GS ratio 0.93.

Against 6° Starboard on the drift scale read off Trk 271°(T) on the outer compass rose.

Example: **Convert GS ratio to GS**
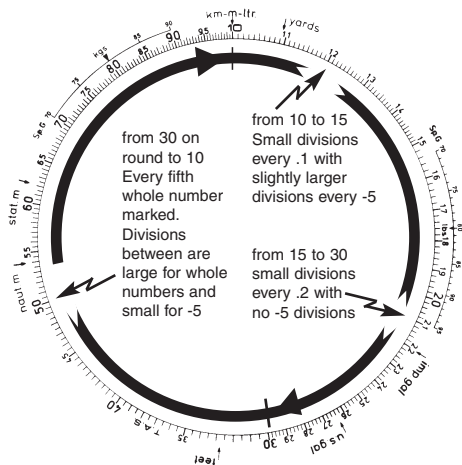*Rough Check:*   0.9 x 300 = 270 kts

Set 1 on the inner scale against 290 on the outer scale against 0.93 on the inner scale read of GS 271 kts on the outer scale.

Answer: **Trk 271° (T), GS 271 kts.**

SOLVING FOR WIND VELOCITY (WV)
knowing Hdg and TAS plus Trk and GS

From known TAS and GS calculate the GS ratio. Rotate the grided disc until the HEADING INDEX is opposite the Hdg direction on the outer compass rose. Read off opposite the known Trk on the compass rose drift on the drift scale.

SPACING The scale is not constant and the values of the various divisions are clarified on the diagram below.

from 30 on round to 10 Every fifth whole number marked. Divisions between are large for whole numbers and small for -5

from 10 to 15 Small divisions every .1 with slightly larger divisions every -5

from 15 to 30 small divisions every .2 with no -5 divisions

NUMBERING The actual numbers printed go from 10 to 95, with some omissions due to compression of the scale. By use of the cursor and the graduated scale it is possible to select any value from 10 to 99.9 but since there are only whole numbers printed on the scale any decimal point has be to mentally inserted. This gives great flexibility, for by mentally moving the decimal point to the right or left a position on the scale can be used to represent a whole range of numbers. For example the second small division to the right of 17 can be used to represent 17.4; 1.74; 17400; 0.00174 etc.

When performing calculations on the circular slide rule particular care has to be taken in the positioning of the decimal point in the final

SOLVING FOR HEADING (Hdg) AND GROUND SPEED (GS)
knowing WV, TAS and required Trk

Convert the wind speed to WV ratio.

Rotate the wind arm to set the **WIND DIRN** line over the wind direction on the outer compass rose. Holding the wind arm in place rotate the grided disc until the **HEADING INDEX** is opposite the Trk direction on the outer compass rose.

Under the WV ratio on the wind arm read off the drift. Further rotate the grided scale until this drift on the drift scale is now opposite the Trk direction on the outer compass rose.

Check the drift now under the WV ratio on the wind arm, as the last adjustment may have altered it.

(a) If it is the same as the drift opposite the track direction on the outer compass rose the computer is correctly set up. Read off hdg opposite the **HEADING INDEX** and the drift and GS ratio under the WV ratio on the wind arm.

(b) If it is not the same as the drift opposite the track direction on the outer compass rose rotate the grided scale until the new drift is opposite the Trk direction on the outer compass rose and check the drift now under the WV ratio on the wind arm. If necessary repeat until the drifts match. The computer is now correctly set up. Read off Hdg opposite the **HEADING INDEX** and the drift and GS ratio index under the WV ratio on the wind arm. Convert the GS ratio to GS.

> *Example:* **TAS 230 kts, WV 000°(T)/40 kts, Trk 055°(T).**
> **What is Hdg°(T) GS and drift?**
> Calculate the WV ratio.
> *Rough check:* 40 divided by 240 = 0.133

Set 1 on the inner scale opposite 230 on the outer scale, opposite 40 on the outer scale read off the WV ratio of 0.174 on the inner scale.

INTRODUCTION

The 1988 models of this range of CRP computers incorporate several changes from previous models. Heavier grade materials are now employed in their construction, the obsolete Pressure Pattern latitude scale has been deleted and the slide now has graduations along the edges for measuring in inches, millimetres and nautical miles (to scales of 1:250,000 and 1:500,000). Minor changes to the layout and clearer numerals make for easier reading and use.

The various ways of using the computer described in this handbook, particularly the solving of triangle of velocity problems, are those employed in Commercial Aviation. These ways of usage, evolved from vast experience and knowledge of the problems involved are consistent in their application and solve all known problems. Many alternative ways of solving problems on the computer exist; mostly they are one-off solutions involving non-standard use of datums. In experienced hands "short cuts" may be acceptable but newcomers are strongly advised not to try them as the end result is usually confusion and frequently they are left with long term hang-ups about the computer.

NOTES