

# Compasses

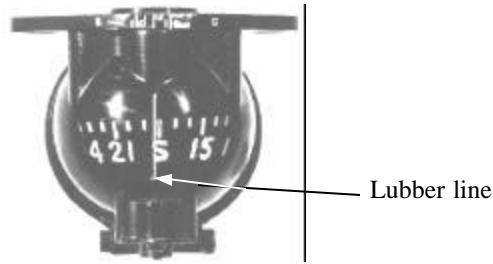


Fig 1.

## Direct Reading Compass

### General

A simple magnetic compass is mandatory equipment on aircraft from single engine trainers to Jumbo jets, despite all the computer technology of the later.

They are simply a bar magnet, within a half-globe that has the points of the compass marked on it. (refer Fig's 1 and 2).

The bar magnet is freely suspended on a pivot, and the compass body is filled with fluid for damping purposes.

The earths magnetic field (called terrestrial magnetism)

The earth can be likened to a large but weak magnet (called terrestrial magnetism), and the earths surface has magnetic field lines which converge to meet at the north and south magnetic poles. Unlike true north and true south, the magnetic poles do not remain in a fixed location, but are constantly moving. The north magnetic pole is situated in Northern Canada, and the south magnetic pole in Victorialand, in Antarctica.

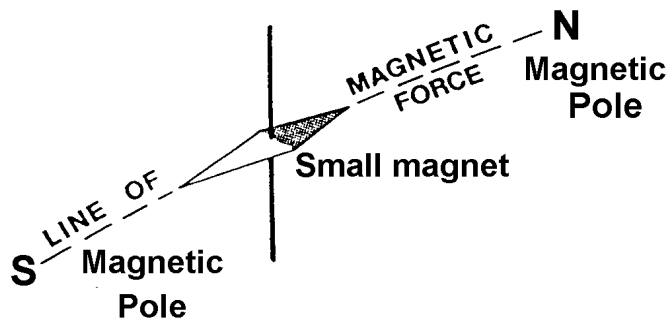


Fig 2. Bar magnet.

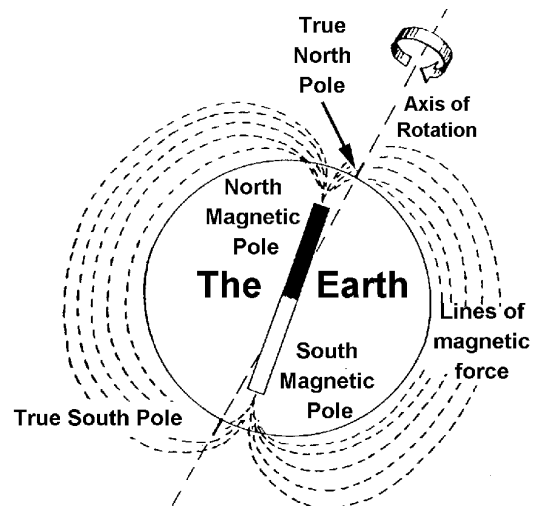


Fig 3. The Earths magnetic field.



**Variation**

The latitude/longitude grid is based on true north/true south. The line connecting these is the axis upon which the earth turns. As True north and Magnetic north are in different locations on earth, it follows that true and magnetic north will vary at most places on earth by some variable amount, which is called "VARIATION". Lines that connect the points of equal variation on earth are called "ISOGONALS". These are shown on IFR navigation charts as dashed green lines.

There are points on earth where true north and magnetic north are the same. The line that connects these points of NIL variation are called "AGONIC LINES". An agonic line passes through Kalgoorlie and Onslow, in Western Australia (refer Fig 4).

**Applying variation**

The following rules apply to convert TRUE headings to Magnetic headings.

Variation EAST = Magnetic track LEAST.

Variation WEST = Magnetic BEST.

eg: 260T/Variation 3E = 257 Magnetic.  
 035T/Variation 10W = 045Magnetic.

Refer fig 5.

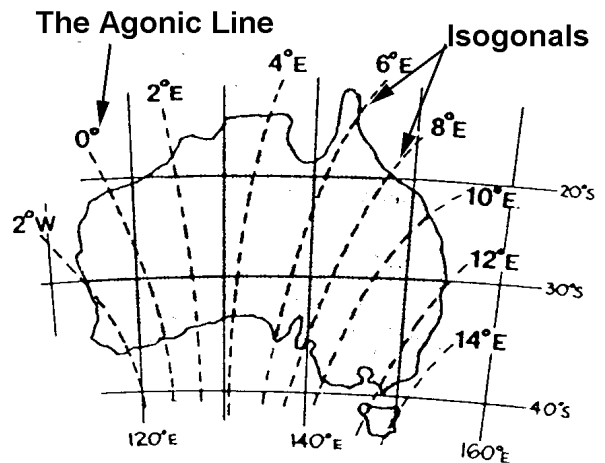


Fig 4. Isogonals and the agonic line.

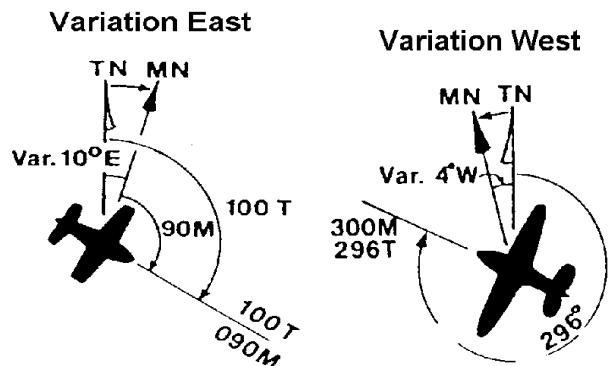


Fig 5. Applying EAST/WEST variation



**Deviation**

The magnetic compass suffers from magnetic field interference from the aircraft structure and components. This is called deviation, and it's magnitude varies from aircraft to aircraft. It causes spurious compass readings, and a compass deviation card is placed in the cockpit so that the pilot can correct for it's effects. The deviation effect of an aircraft can be changed when a new radio unit, or GPS unit is added or subtracted, and any such change to the aircraft fittings mean that the compass must be "SWUNG" and a new deviation card produced (refer fig 6). Other objects that can cause transient deviations include, mobile phones (whether turned on or off), transistor radios, books with metal binders, headphones, electronic calculators, and metal navigation slide rules.

| FOR     | STEER |
|---------|-------|
| N (360) | 003   |
| E (090) | 091   |
| S (180) | 180   |
| W (270) | 267   |

Fig 6. Typical compass deviation card.



**Keep ferrous metal objects away from the compass region.**

**Magnetic Dip**

Near the equator the lines of the earth's magnetic are parallel to the earth's surface, but as they approach the magnetic poles they progressively dip downward, until at the poles they are vertical to the earth's surface. The effect on the bar magnet within a direct reading magnetic compass is to cause it to dip also, making it unusable near the poles. To counter this the pivot point on which the bar magnet swings is deliberately placed at a position other than the magnet's centre of gravity (CG). This counters magnetic dip up to a point, but introduces turning and acceleration errors (refer Fig's 7, 8, 9).

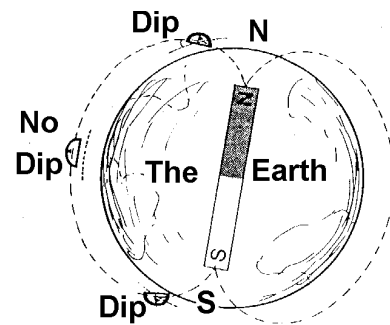


Fig 7. Magnetic Dip toward poles.

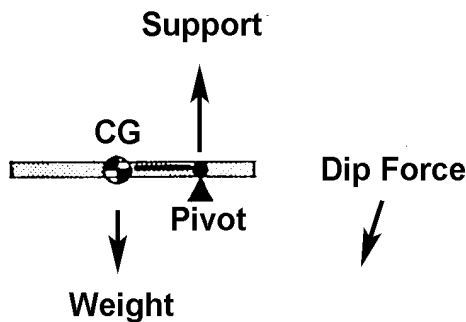


Fig 8. Pivot point vs compass CG.

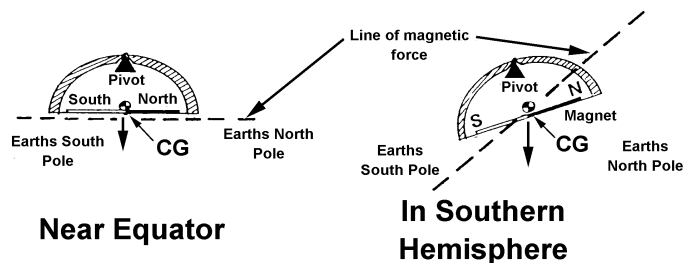


Fig 9. Pivot point vs compass CG.



The strength of the magnetic field is reasonably constant at all points on the earth . It's total strength can be divided into horizontal and vertical components. The horizontal field is parallel to the earth surface, The vertical component causes the needle to dip. Near the equator the horizontal component is strongest, whereas near the pole the vertical component is strongest. Refer Fig 10 a and 10 b.

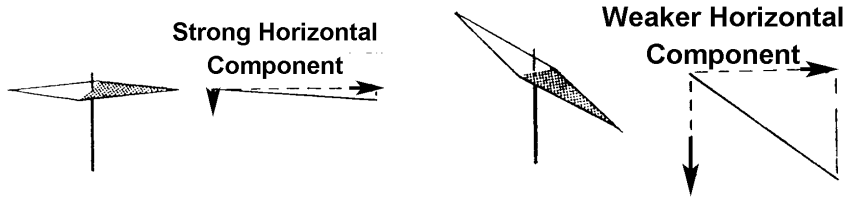


Fig 10a. Near equator.

Fig 10b. Near magnetic poles.



**Magnetic dip is greatest at the magnetic poles.**

**Construction of a floating magnetic compass**

The compass body is filled with fluid which provides damping, thereby decreasing unwanted oscillations due to turbulence of the magnet and float. Steadier compass indications result. The fluid also decreases friction at the compass pivot point. The fluid should fill the compass, and no air bubbles or compass fluid discoloration should be present.

The clear compass face (window) has on it a vertical line called a “LUBBER LINE”, so that the pilot can use it as a datum to set the required heading. How the pilot views the compass is represented in Fig 11.

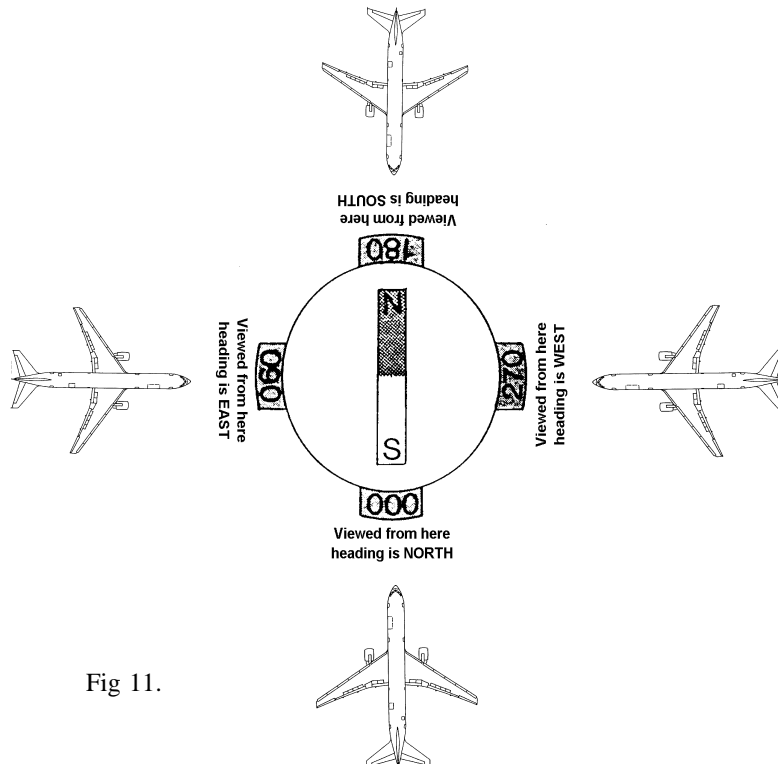


Fig 11.



**Effects of aircraft acceleration**

Because we have had to place the pivot at a different position than the bar magnets C of G to help alleviate compass dip, any accelerations/decelerations can cause some transient incorrect compass readings during the acceleration/deceleration period. This error is most pronounced on east/west headings, and can be considered nil on north/south headings. The reason that east/west headings produced the largest acceleration/deceleration errors is because the bar magnet is always aligned with magnetic north/south, and the moment arm between the pivot point and the C of G is at its worst. Refer fig 12a and 12b.

**In Southern Hemisphere**

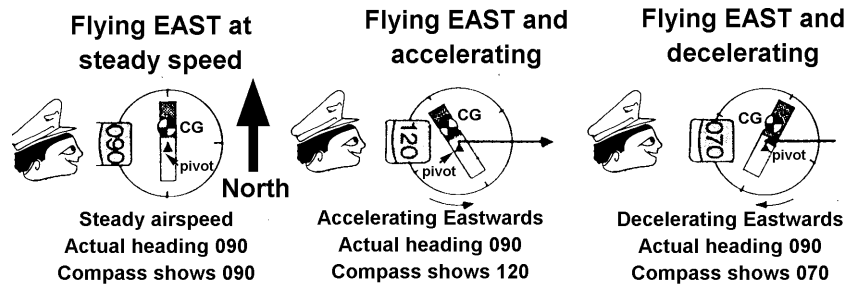


Fig 12a. Effect of acceleration/deceleration travelling EAST.

**In Southern Hemisphere**



Fig 12b. Effect of acceleration/deceleration travelling WEST.



In assessing the error which may occur we use the **SAND** rule.  
 Apparent turn **S**outh when **A**ccelerating.  
 Apparent turn **N**orth when **D**ecelerating.

| Travelling  | Accel/Decel    | Apparent Turn | Apparent Turn | Apparent Turn      |
|-------------|----------------|---------------|---------------|--------------------|
| North/South | Accel or Decel | Nil           | Nil           | Nil                |
| North/South | Accel or Decel | Nil           | Nil           | Nil                |
| <b>EAST</b> | Accelerating   | RIGHT         | SOUTH         | Increasing numbers |
| <b>EAST</b> | Decelerating   | LEFT          | NORTH         | Decreasing numbers |
| <b>WEST</b> | Accelerating   | LEFT          | SOUTH         | Decreasing numbers |
| <b>WEST</b> | Decelerating   | RIGHT         | NORTH         | Increasing numbers |



The following relates to a compass corrected for magnetic dip in the southern hemisphere. In the northern hemisphere the situation is reversed.

Accelerating toward the east, the compass CG (near the north seeking end of the magnet) is left behind. This swings the compass card so that it indicates an “apparent” turn to the right (south). During the acceleration, the pilot will read the compass heading more southerly than the actual true heading. The pilot should allow the compass to settle down after the acceleration is completed and NOT react to the transient compass reading.

Decelerating toward the east, the pivot slows down with the rest of the aircraft and the Cg of the magnet due to it’s inertia, tries to advance. The compass card rotates showing an “apparent” turn to the left onto decreasing numbers to the north.

Accelerating toward the west, the CG of the magnet and compass card (Near the north seeking end of the magnet) is left behind. This swings the compass card such that it indicates an “apparent” turn to the left (south) onto decreasing numbers. The compass will indicate a heading that is more southerly than is actually the case.

Heading west, a deceleration will cause the CG to apparently advance ahead of the pivot, an the net result is an “apparent” turn to the right (north) onto increasing numbers. It will appear that the aircraft has turned toward the north. During all of the above the pilot held the wings level.

Another error that is induced by the need to place the pivot away from the CG to counter magnetic dip is turning errors.

### Turning Errors

This error is at it’s maximum when turning onto north or south, not being a problem on east west headings. When turning onto new headings, especially those near north or south we apply the “ONUS” rule (refer fig 13).

- When turning onto northerly headings **OVERTurn** past the required heading.
- When turning onto southerly headings **UNDERTurn**, and rollout of the turn before the required heading.



Fig 13 shows the turning errors (in brackets) on the major points of the compass. They assume a standard rate turn (ie: 3 degrees per second).

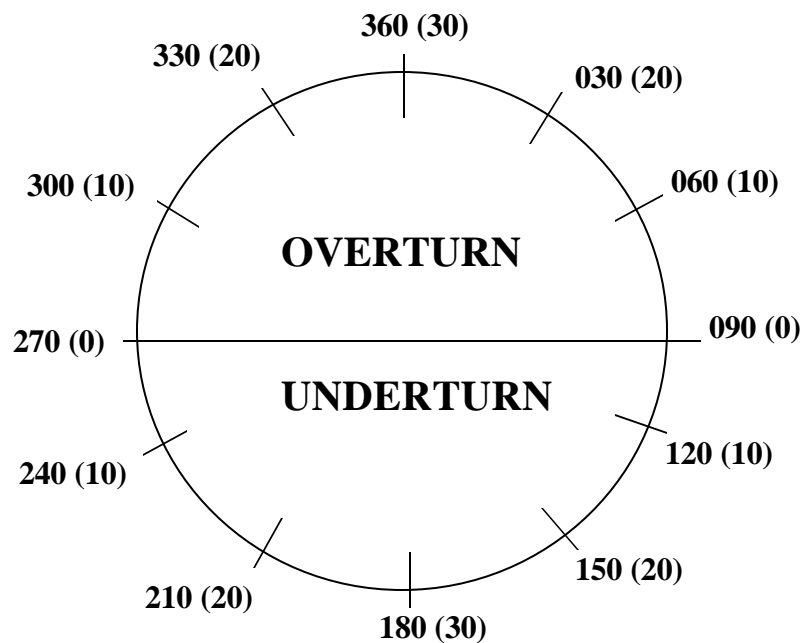


Fig 13. Turn correction on major compass headings.



**Acceleration errors are greatest on EAST/WEST headings.**



**Turning errors are greatest on NORTH/SOUTH headings.**



**Turning errors are NIL on EAST/WEST headings.**

**Some examples of applying the ONUS rule:**

1. Current heading 180M. Aircraft turns right onto required heading of 360M. What is the rollout heading ?  
Answer: OVERSHOOT north by 30 degrees. Rollout of turn when heading is 030M.
2. Current heading 120. Aircraft turns left onto required heading of 300M. What is the rollout heading ?  
Answer: OVERSHOOT 300 by 10 degrees. Rollout of turn when heading is 290M.
3. Current heading 030M. Aircraft turns right required heading of 150M. What is the rollout heading ?  
Answer: UNDERSHOOT 150 by 20 degrees. Rollout when heading is 130M.



**Now attempt compass assignments 1, 2, and 3.**