Basic Instruments 2 - Altimeters

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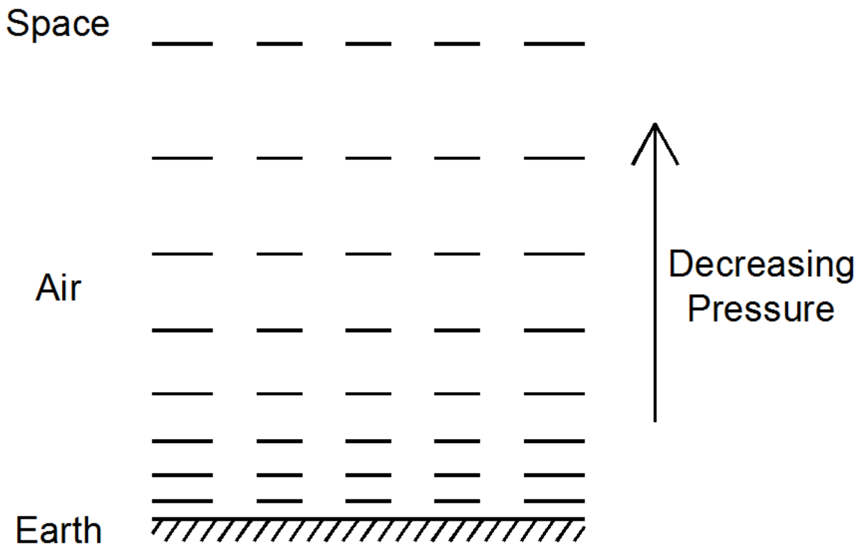
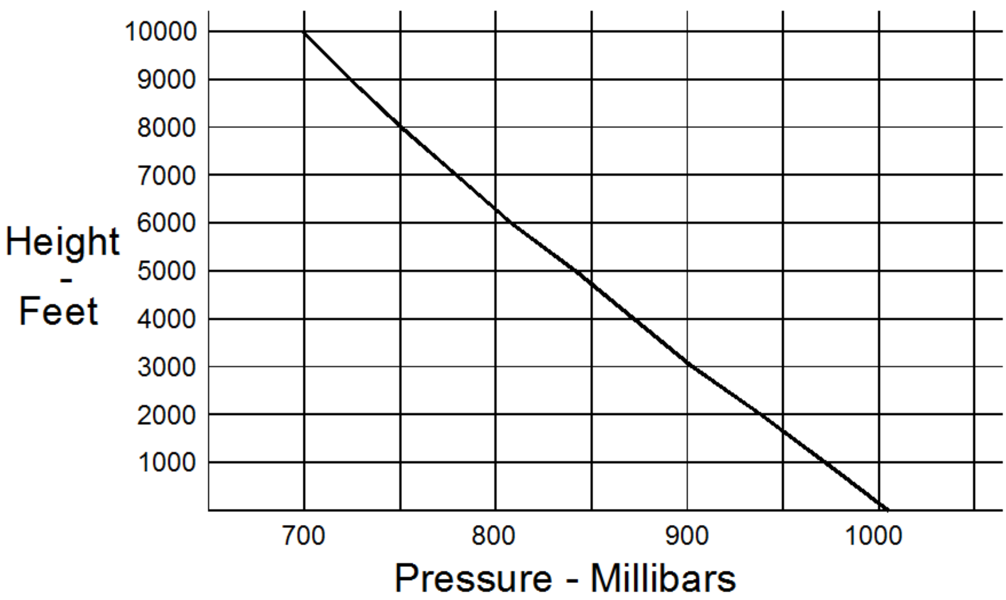
Measurement of altitude in aviation is based almost entirely on air pressure. We know that air pressure decreases as we ascend.



Although the condition of the atmosphere varies considerably the international scientific community decided on a "standard atmosphere" which is used for altitude measurement in aviation. In a "standard atmosphere" the pressure falls with height in a mathematically defined way. This graph shows how pressure in a a standard atmosphere decreases up to 10000 feet, although it is defined to much higher altitudes.

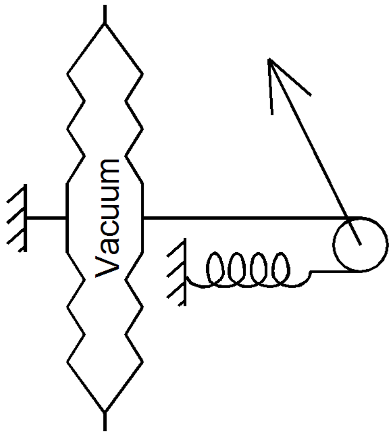


Temperature is also defined but aviation altitudes are measured by pressure alone. Note that in the standard atmosphere the pressure at sea level is

1013.25 millibars and drops by about 1 millibar for every 30 feet of climb. As 0.25 millibars corresponds to about 7 feet, 1013 millibars is good enough for our purposes.

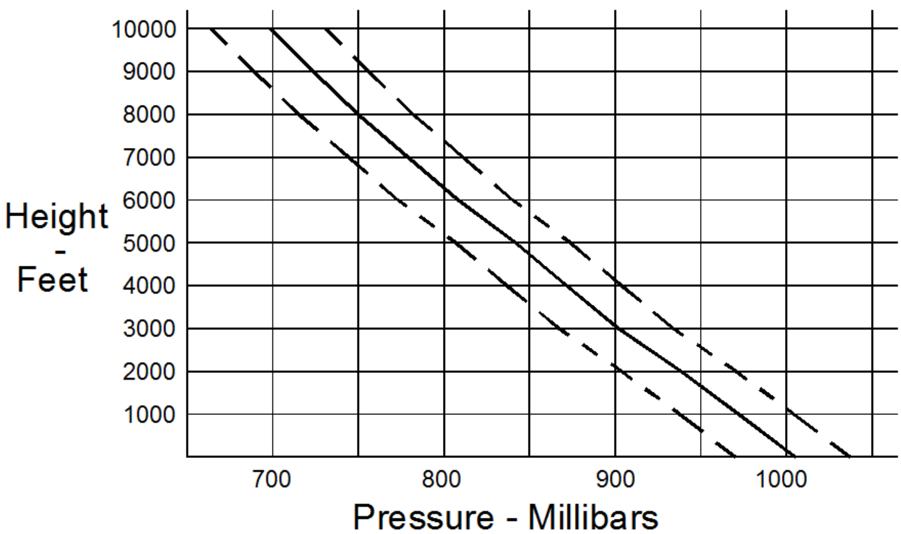
Note that a millibar is the same as a hectopascal.

To make an altimeter we can use a sort of barometer mechanism “working backwards” so that the needle rotates clockwise to indicate decreasing pressure.



Mechanical altimeters work on this principle with a sort of diaphragm chamber called an aneroid which has a partial vacuum inside. As the altimeter goes up the reducing air pressure causes the chamber to expand and the needle to rotate.

That's fine, but we know the pressure of the atmosphere changes with the weather which cause our altitude reading to go up and down. The line on our graph is moved to the right of the line of the standard atmosphere if the pressure is higher, and vice verse.



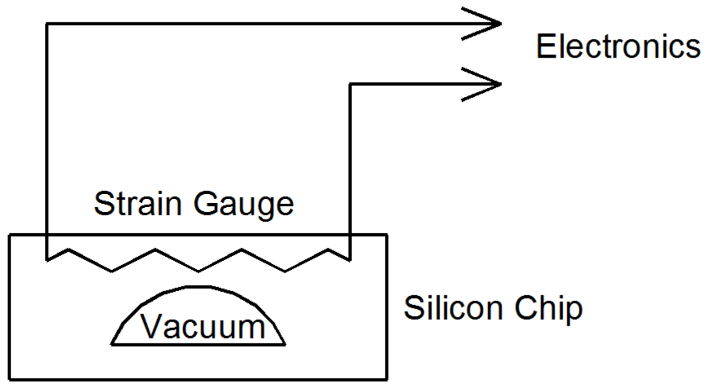
We have to adjust our altimeter to allow for these pressure changes. A standard aviation altimeter has a knob for doing this.

On this altimeter the setting knob is at the bottom left. It can be turned by the pilot to set the indicated altitude to a particular value. However, as well as affecting the indicated altitude turning it also directly changes the numbers in the small window on the right. This window is called the millibar subscale, and shows 992 millibars in this picture. The number shown indicates the pressure at which the altimeter will read zero feet. If this is set by the pilot to 1013 millibars the altimeter will read correct altitude in a standard atmosphere.

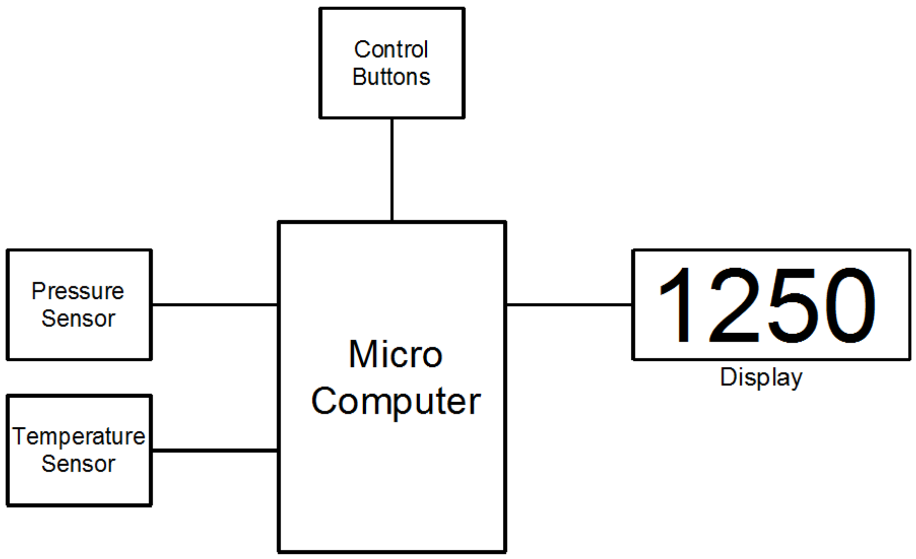
All altimeters near each other which are set to the same pressure on the subscale will read the same at the same altitudes. A pilot can set the subscale to a pressure given to him by air traffic controllers to ensure he is flying at a particular height relative to other aircraft, airspace boundaries or the surface of an airfield.

If you get the chance it is very useful to spend a while fiddling with a standard altimeter. Note that the subscale on some altimeters may be calibrated in inches of mercury instead of millibars.

For paragliding and hang-gliding we normally use electronic instruments. Our aneroid is a tiny cavity in a silicon chip called a pressure sensor.



A strain gauge built into the chip is connected to the electronics to measure the pressure. All modern instruments are, of course, microcomputer based and schematically are a bit like this.

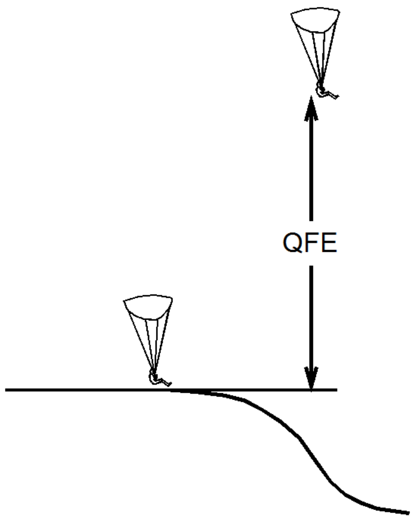


Information from the pressure sensor is interpreted by the microcomputer and sent to the display. Because pressure sensors are also sensitive to temperature we also have a temperature sensor so the microcomputer can apply compensation for temperature changes.

Lastly we have some control buttons to make a pressure adjustment similar to the setting knob on the standard altimeter. Most PG and HG instruments do not have a millibar subscale as does a standard altimeter. The pilot does not know what reference pressure is actually set and must make his adjustment by looking at the displayed altitude.

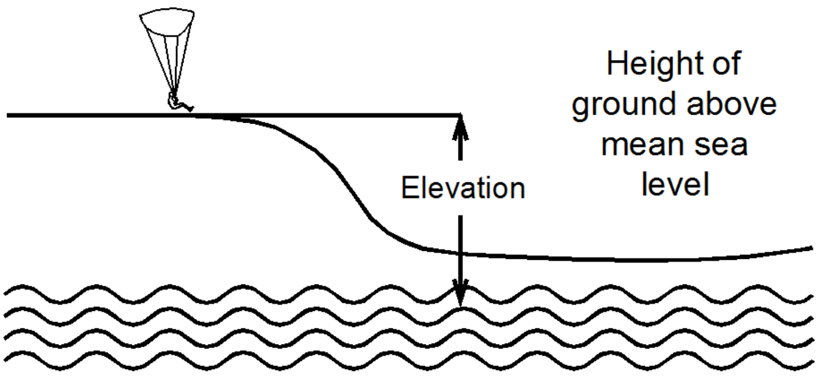
Altimeter Setting

The simplest way to set an altimeter is to adjust it to read zero on the ground at our launch point. This way it will read our height above take off.

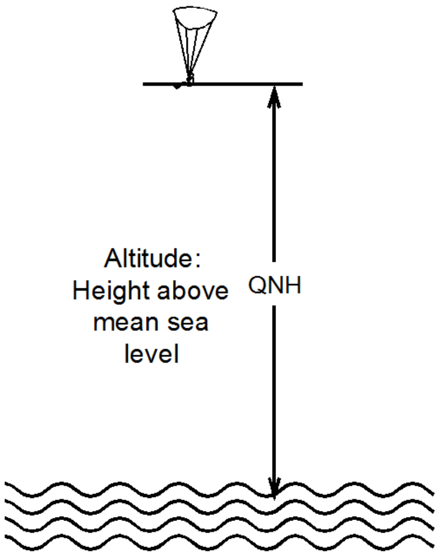


This setting is often known as QFE. Apart from showing our height gain it is not much use to PG and HG pilots.

A more useful way is to set the altimeter at take off so it reads the height of our launch point above mean sea level (AMSL). This height is known as the "elevation" of the take off.



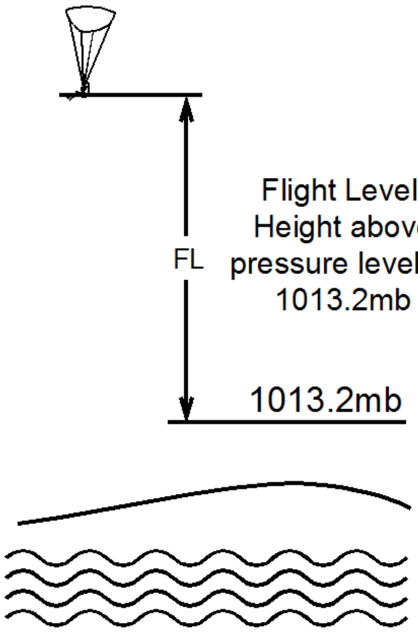
This height is known as the "elevation" of the take off. Our altimeter will now read our height above mean sea level, which is our altitude.



This setting is sometimes known as QNH and is the normal setting for cross country flying to ensure we do not enter airspace. Alternatively if our altimeter has a millibar subscale we could set it to regional QNH pressure obtained from a nearby airfield.

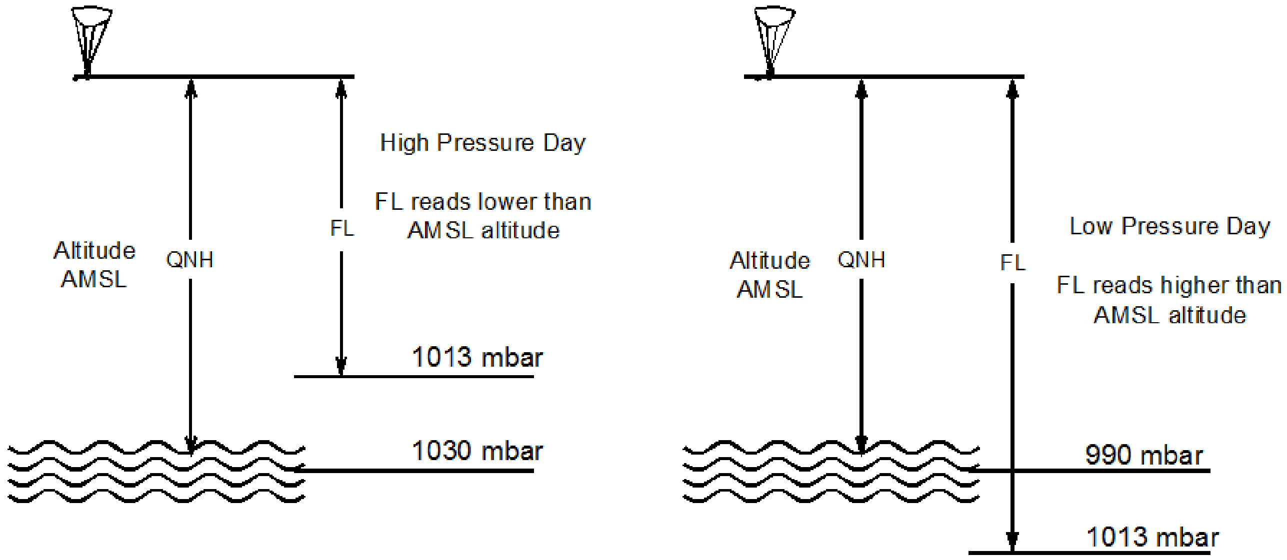
There is one more setting we need to know.

For flights at relatively high altitudes height is often measured as a flight level. This is the height measured above a pressure level of 1013.25 millibars.



It is stated in hundreds of feet to the nearest 100 feet. 5500 feet above a pressure level of 1013 millibars would be given as Flight Level 55 (FL55).

The actual height of FL55 above the ground will change as the air pressure changes. On a high pressure day the flight level will be higher than the actual height AMSL and vice verse.



Note that on the low pressure day the level at which the pressure is 1013 millibars and the height at which our altimeter reads zero is below sea level! This setting is known as QNE. Because most PG and HG electronic altimeters do not have a millibar subscale they usually have a means of selecting 1013 millibars as a reference. Some instruments have a separate display for flight level.

<u>GPS Altitude</u>

GPS altitude on PG and HG instruments can be extremely inaccurate and unreliable even when an instrument is producing an accurate 2D location. It should not be used for flying. There are plenty of other reasons, many of which can be examined in an article published in Cross Country Magazine in 2011 written by Mark Graham.

http://www.xcmag.com/2011/07/gps-versus-barometric-altitude-the-definitive-answer/

If you cannot understand that article do not worry. You are not alone. In the past a number of pilots making decisions about the acceptability of GPS altitude in PG and HG competitions have not been able to understand it either and there have been a lot of problems.

A simpler explanation is available from the instrument manufacturer Naviter.

http://www.naviter.com/2015/02/gps-altitude-vs-pressure-altitude/

To this explanation I would add that the examples given were probably recorded in conditions of good GPS reception. In poor conditions things could be much worse.

Until now at least, the PG and HG world would have been better off if GPS systems had not been capable of providing an altitude reading at all.

Calibration

Altimeter pressure sensors are probably the only parts likely to require calibration at any time. Manufacturers release very little information on this issue but should be consulted about calibration requirements if nothing is mentioned in the manual. It is a good idea to cross check your altimeter with another instrument, preferably new or recently calibrated, from time to time.