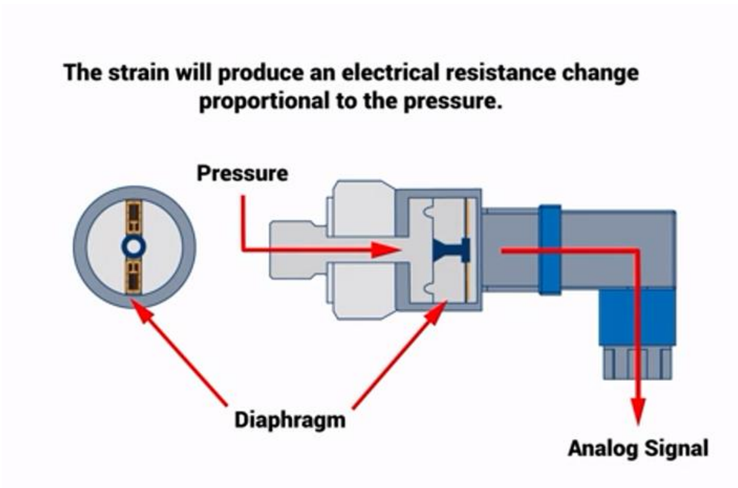
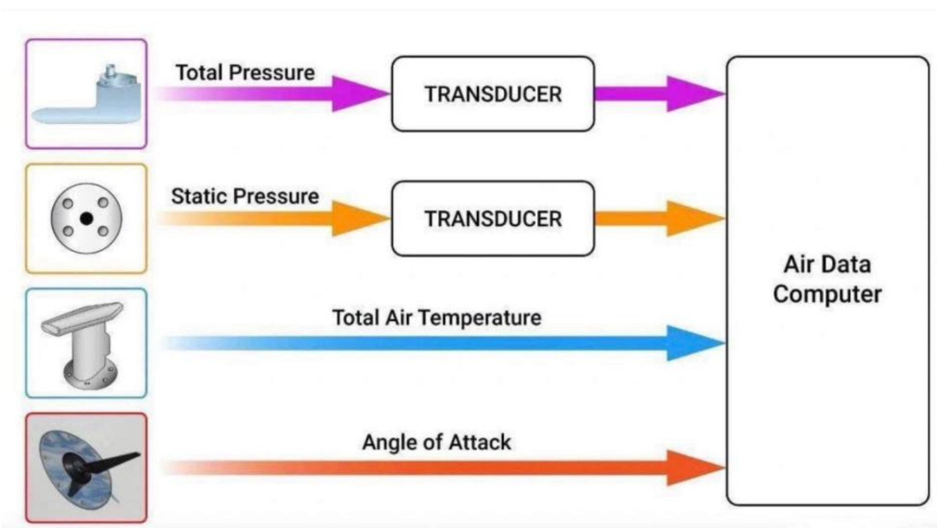
AHRS, ADC and Glass panel Primary flight displays. How they work.

From "*Private, Commercial, Sport Pilot Training Manual"* at RealCFI.com

Pitot Static Instruments: Use the same concepts as the above mechanical instruments, however the pressures are measured with pressure transducers. The pressure transducer has a diaphragm that flexes against the pressure and its motion is converted to an electrical signal proportionate to the pressure.



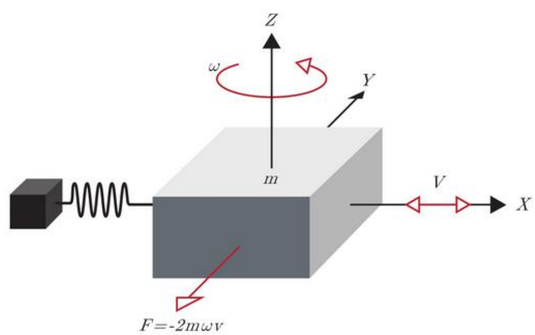
The pressure information is processed by an air data computer (ADC). IAS is calculated in the same manner (Stagnation – static = dynamic) and sent to the electronic display. The ADC will also use outside air temperature and report Altitude, Vertical Speed, and calculate TAS. Ground speed is obtained from the GPS. Then winds aloft, cross track, wind correction and other parameters can be calculated in the Primary Flight Display.



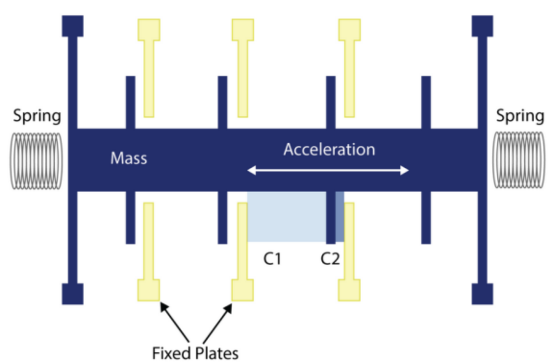
Attitude and Heading Reference systems (AHRS): Uses many of the same principles to determine aircraft attitude and heading as the mechanical instruments.

Attitude information: Uses a combination of a micro electro-mechanical device (MEM) and accelerometers to determine aircraft attitude.

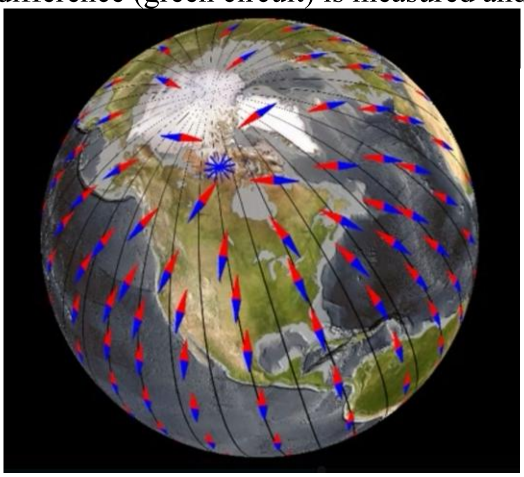
MEM Gyro chip. Both "rotating" gyros in mechanical attitude indicators and "oscillating" gyros in MEM chips (see below) work on the principle of momentum. A mass in motion will resist being displaced. In the mechanical gyro, the aircraft rotates around the gyro (rigidity in space). The MEM gyro detects displacement of the mass (similar to Coriolis causing winds to displace east and west with rotation of the earth). In the schematic below, a small mass is oscillated rapidly along the X axis by electrical impulses. This imparts a momentum that causes the mass to resist displacement. When the aircraft turns or rotates (as seen by "ω" and arrow), it causes the mass to displace laterally along the Y axis. This movement is detected by a change in electrical capacitance and calibrated to register the change in aircraft attitude.



Accelerometers: Microscopic weights (mass) on a spring. In the diagram below, if the device is moved abruptly to the right (acceleration force), the "mass" resist motion and compress the spring on the left. The rate and magnitude of deflection of the mass on the spring is measured electrically by changes in capacitance (C1 and C2 in the diagram). Three accelerometers are placed in three directions (X, Y, & Z axis) and determine accelerations and decelerations in each of three planes of space.



Magnetometer: There are several variations of this device. Older avionics used a "Flux Gate" magnetometer that is large and heavy (see description in the PHAK). The most common type used in modern avionics (and handheld electronics) uses the "Hall effect". An electrical current is passed through a conductive plate (Hall element- see below). Normally, the current (red circuit) would pass in a straight line through the middle of the plate. The earth's magnetic field runs in very specific paths from the north to the south. Depending on how the magnetic field passes through the plate it displaces the current to one side of the plate and creates "Polarization" or voltage difference. This voltage difference (green circuit) is measured and calibrated to determine magnetic direction.



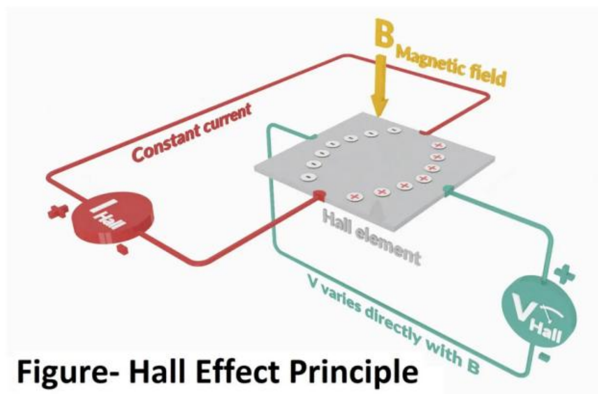


Figure- Hall Effect Principle

In the figure above, the Earth's magnetic field travels in lines from the magnetic North to South. These magnetic lines are "polarized" as seen by the red and blue arrows. As the lines of magnetic "flux" cross the "hall plate" the current is displaced in specific directions based on the "polarity" and direction of the magnetic field. *Micro magnetometers use hall effect to detect magnetic flux and direction.*