Argus

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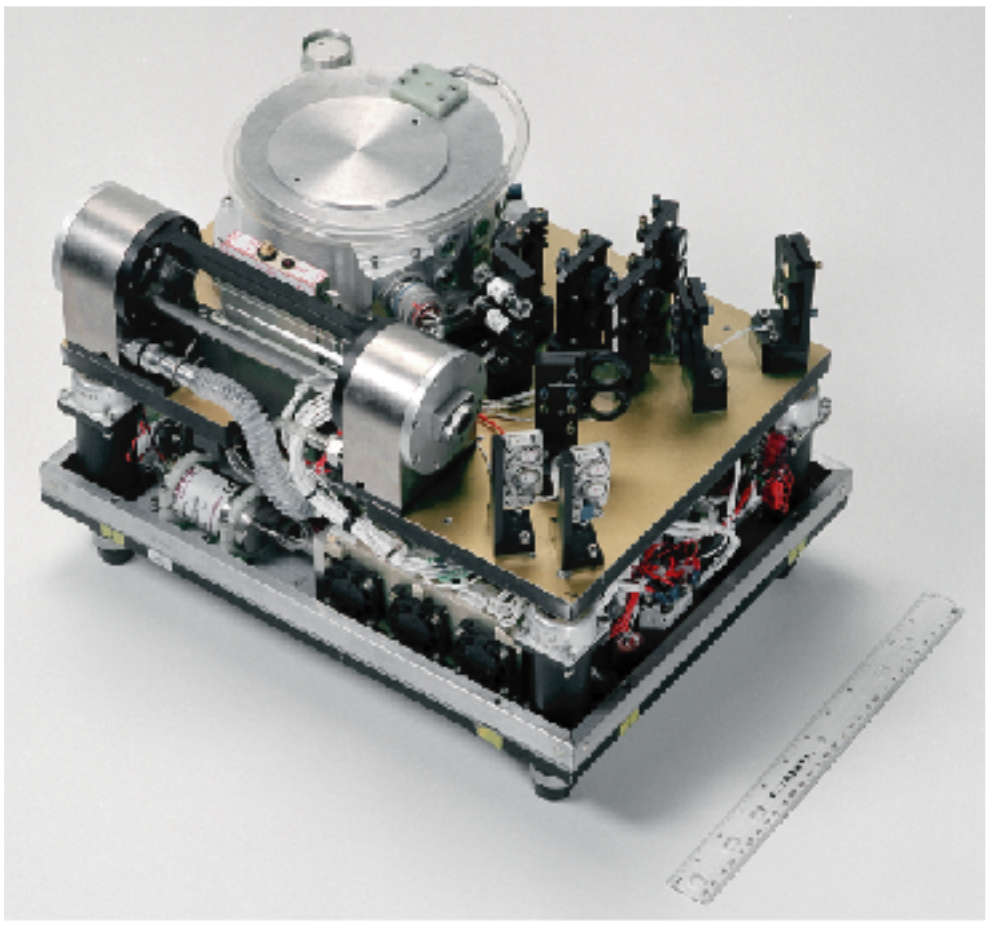
Instrument Description

Argus is a two channel, tunable diode laser instrument set up for the simultaneous, *in situ* measurement of CO (carbon monoxide) and CH_4 (methane) in the troposphere and lower stratosphere. The instrument measures 40 x 30 x 30 cm and weighs 21 kg. An auxiliary, in-flight calibration system has dimensions 42 x 26 x 34 cm and weighs 17 kg.

The instrument is an absorption spectrometer operating in rapid scan, second-harmonic mode using frequency-modulated tunable lead-salt diode lasers emitting in the mid-infrared. Spectra are co-added for two seconds and are stored on a solid state disk for later analysis. The diode laser infrared beam is shaped by two anti-refection coated lenses into an f/40 beam focused at the entrance aperture of a multi-pass Herriott cell. The Herriott cell is common to both optical channels and is a modified astigmatic cell (New Focus Inc., Santa Clara, California).



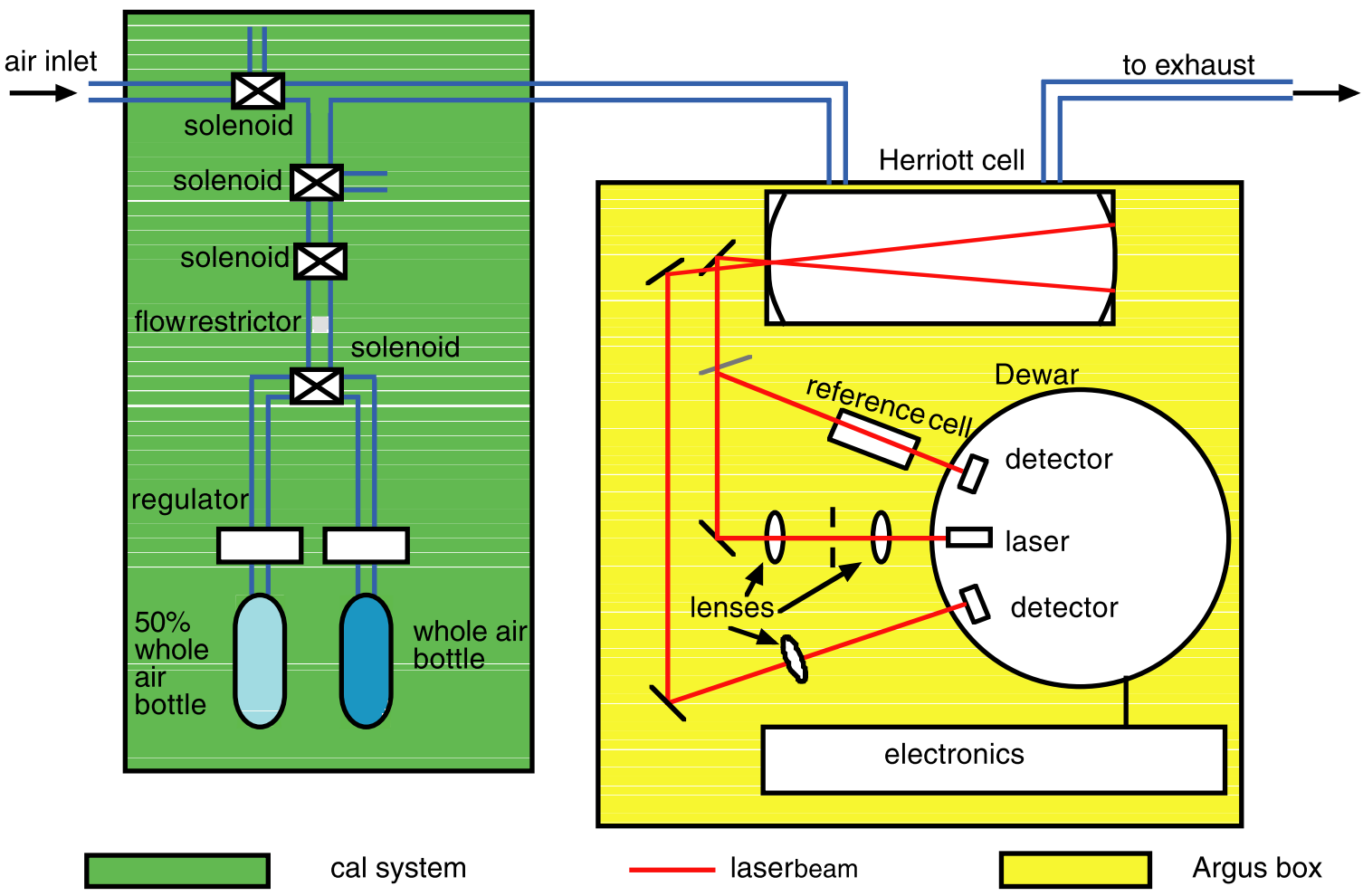
The aspherical mirrors are coated with protected silver for optimal infrared reflectivity. The cell is set up for a 182-pass state for a total path of 36m. The pass number can be confirmed by visual spot pattern verification on the mirrors observed through the glass cell body when the cell is illuminated with a visible laser beam. However, instrument calibration is always carried out using calibrated gas standards with the Argus instrument operating at its infrared design wavelengths, 3.3 and 4.7 micrometers respectively for CH_4 and CO detection. The electronic processing of the second harmonic spectra is done by standard phase sensitive amplifier techniques with demodulation occrring at twice the laser modulation frequency of 40 kHz. To optimize the second-harmonic signal amplitude in a changing ambient pressure environment the laser modulation amplitude is updated every 2 seconds to its optimal theoretical value based upon the measured pressure in the Herriott cell.

CO and CH_4 Measurement Characteristics

Tracer	P (mb) / Alt (km)	Data Rate (Hz)	Precision (ppb)	Accuracy (%)1σ
CO	268 / 10	0.5	1.1	3
	77 / 18	0.5	2.2	3
CH_4	268 / 10	0.5	8.1	1.6
	77 / 18	0.5	8.7	1.6

Calibration

Argus is regularly calibrated in the laboratory against a CMDL (Climate Monitoring and Diagnostics Lab) whole air standard for CH_4 and CO. Flow-mixing of this standard with a zero gas provides us with absolute calibration and linearity data as inputs to the *in situ* flight recorded analysis. During field operations Argus is calibrated in the lab both before and after every flight operation with the instrument maintained in its flight setup configuration throughout the calibrations. Argus also employs an in-flight calibration system providing real time calibrations and tightly constrained uncertainty estimates of the returned data.



Data Analysis

The post-flight data reduction uses a non-linear, least squares Marquardt-Levenberg fitting procedure where theoretical fitting function is the second Fouier component of the modulated Voigt absorption line-shape. One parameter returned by the fitting procedure is the molecule number density (CO and CH_4) in the Herriott cell. This is converted to mixing ratio using the measured gas density in the cell. Argus then reports molecule mixing ratio at 0.5 Hz data rate to the data archive.