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GAS CHROMATOGRAPHY
POSSIBLE APPLICATION OF ADVANCED INSTRUMENTATION DEVELOPED FOR SOLAR SYSTEM EXPLORATION TO SPACE STATION CABIN ATMOSPHERES

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Gas chromatography (GC) technology has been under development for flight experiments in solar system exploration for some years. GC is a powerful analytical technique where relatively simple devices can separate individual components from complex mixtures and then make very sensitive quantitative and qualitative measurements. It is particularly suited to monitoring samples containing mixtures of fixed gases and volatile organic molecules. GC has been used on the Viking mission in support of life detection experiments and on the Pioneer Venus Large Probe to determine the composition of the venusian atmosphere. A flight GC is currently being developed to study the progreess and extent of STS astronaut denitrogenation prior to extravehicular activity. Advanced flight GC concepts and systems for future solar system exploration are also currently under study. Studies include miniature ionization detectors and associated control systems capable of detecting from ppb up to 100 percent concentration levels. Further miniaturization is being investigated using such techniques as photolithography and controlled chemical etching in silicon wafers. Novel concepts such as ion mobility drift spectroscopy and multiplex gas chromatography are also being developed for future flight experiments. These powerful analytical concepts and associated hardware are ideal for the monitoring of cabin atmospheres containing potentially dangerous volatile compounds and could be applied with minimal development.

TABLE 1

PIONEER VENUS LGC RESULTS

SAMPLE NUMBER	1	2	3
ALTITUDE, KM	51.6	41.7	21.6
PRESSURE, BARS	0.7	2.9	17.8
GAS	% CONCENTRATION		
CO_2	95	96	96
N_2	4.6	3.5	3.4
H_2O	<0.06	0.52	0.14
	ppm		
O_2	44	16	
Ar	60	64	67
CO	32	30	20
Ne	8	11	4
SO_2	<600	180	185

Figure 1 Pioneer Venus short column chromatogram of 24 km sample, showing raw data points. Solid line shows detector signal at a range of 0.7 to 1.6 mV. Dashed line shows detector signal at a range of 0.7 to 900 mV. Inset at right is expanded view of SO_2 peak.

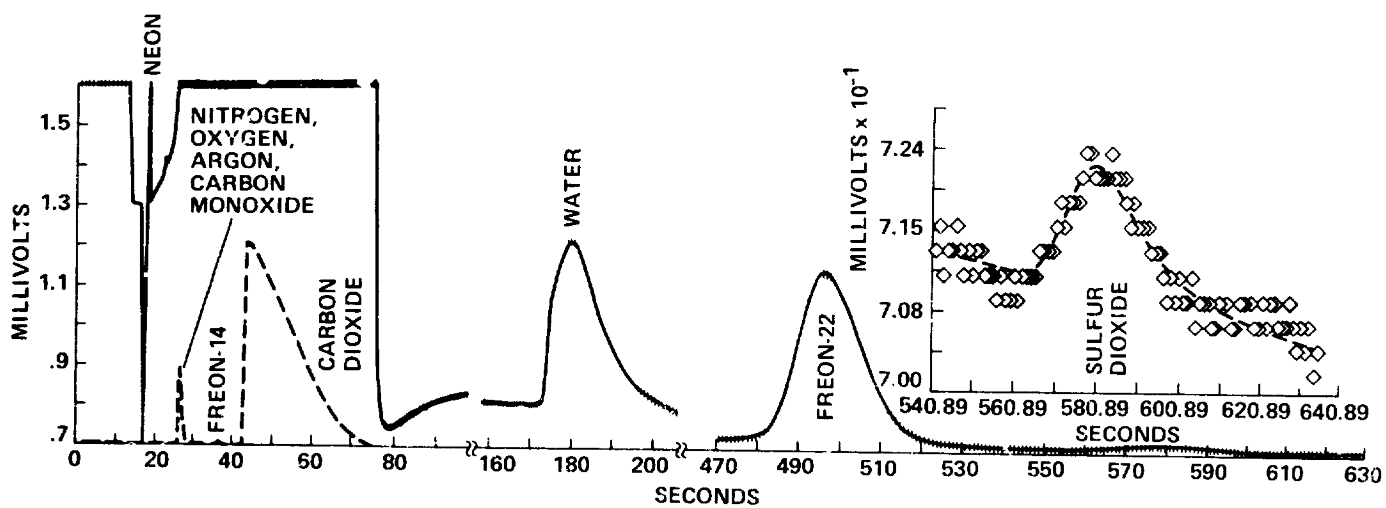

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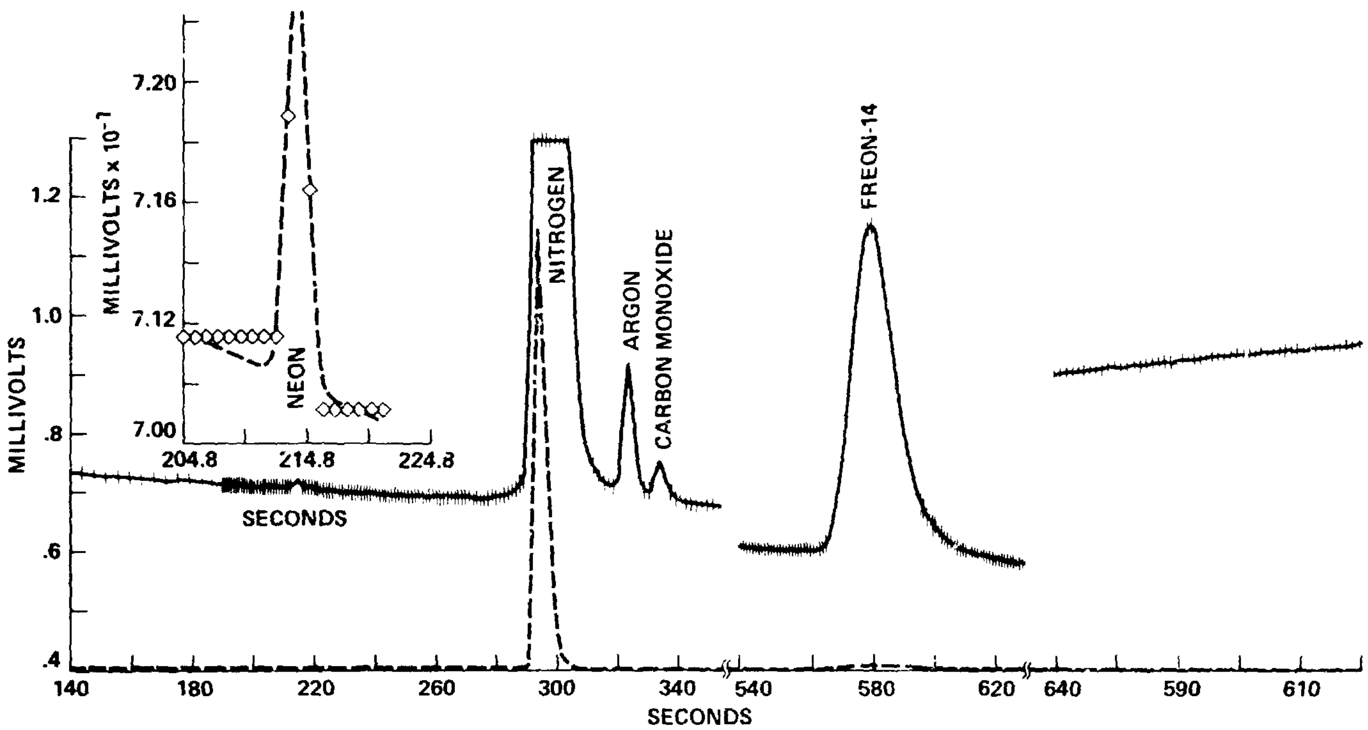
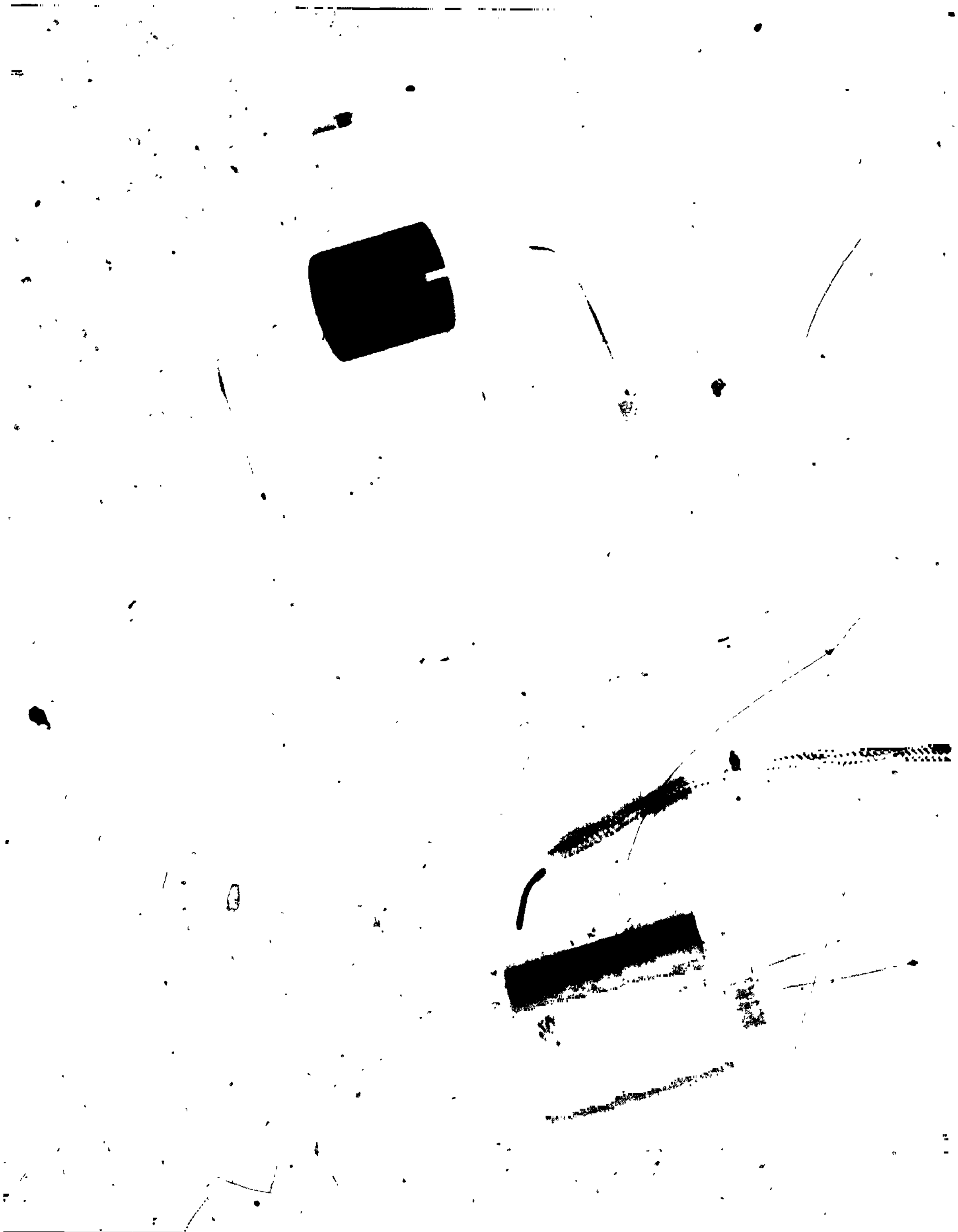
Figure 2 Pioneer Venus long column chromatogram of 24 km sample, showing raw data points Solid line show detector signal at a range of 0.6 to 1.5 mV Dashed line shows detector signal at a range of 0.6 to 90.6 mV Inset at left is expanded view of Neon peak.





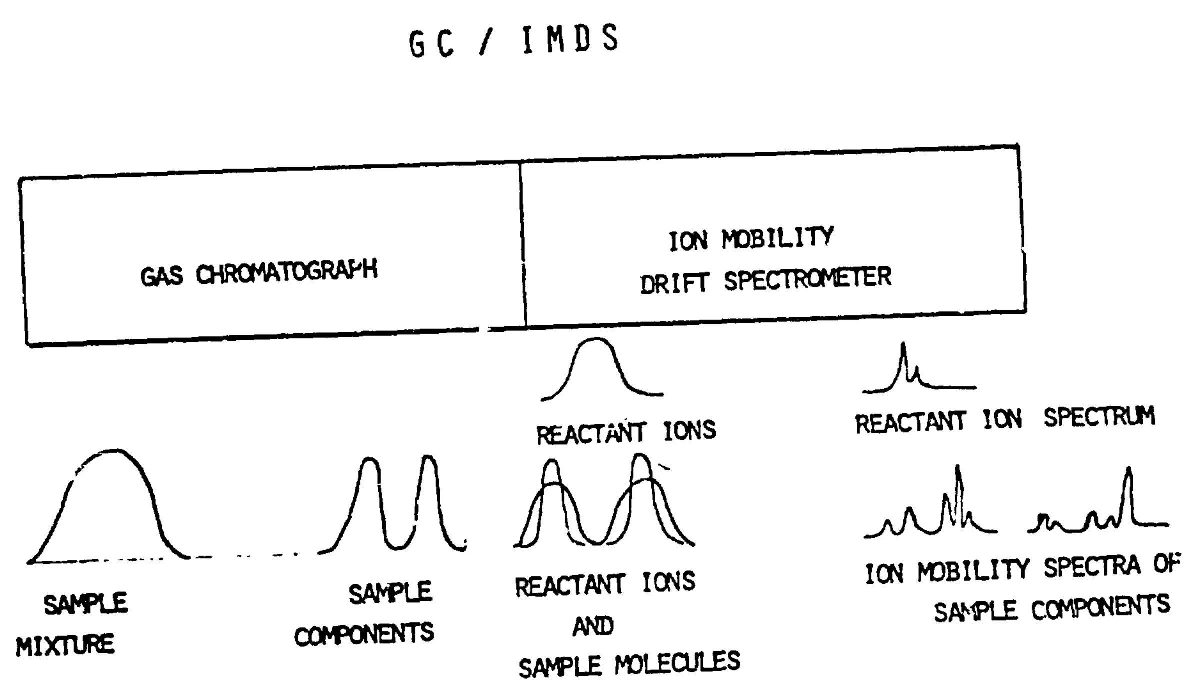


Figure 4: Gas Chromatograph separates components of sample mixture. IMDS reactant ions ionize each sample component as it elutes from the GC column forming product ions. These product ions are separated in the drift tube according to their size and structure forming Ion Mobility Spectra of the sample components.

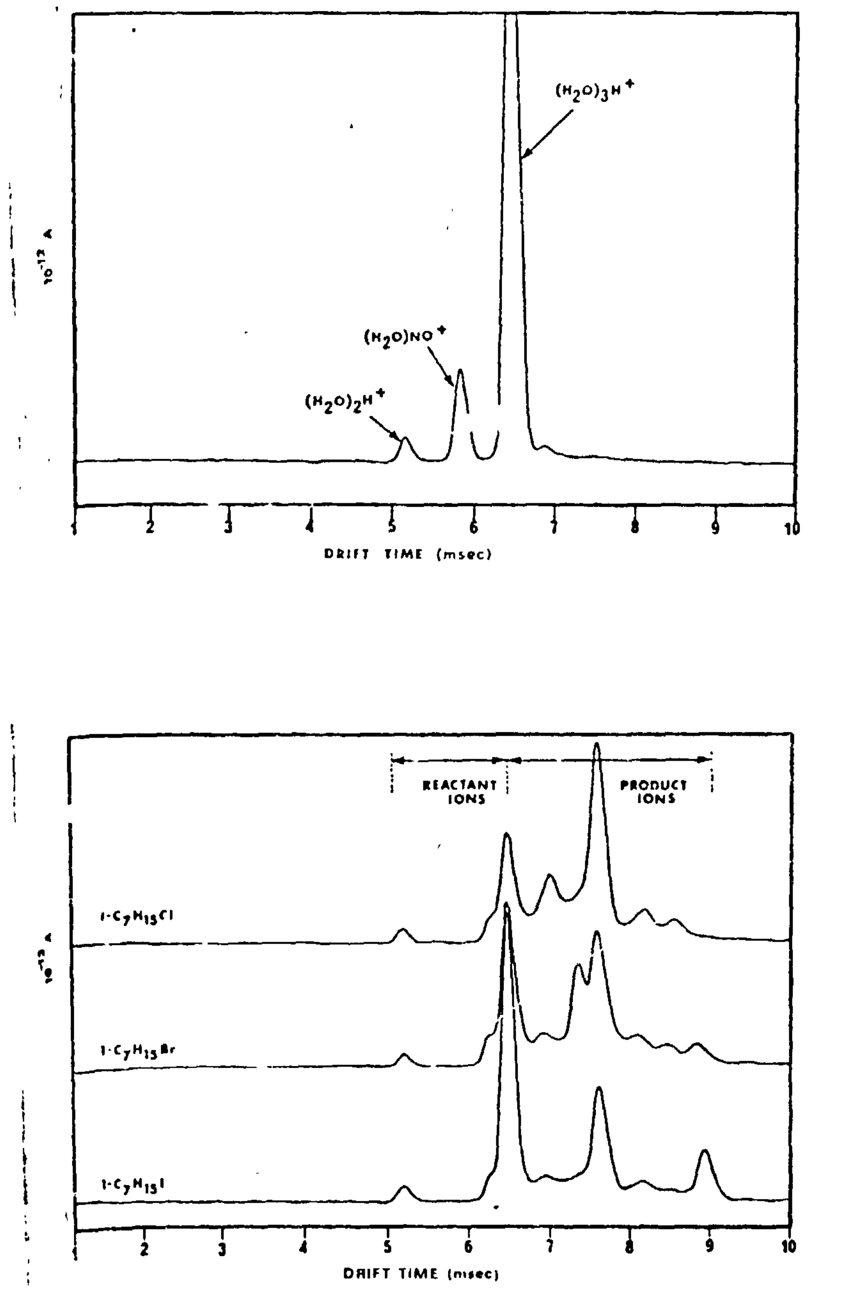
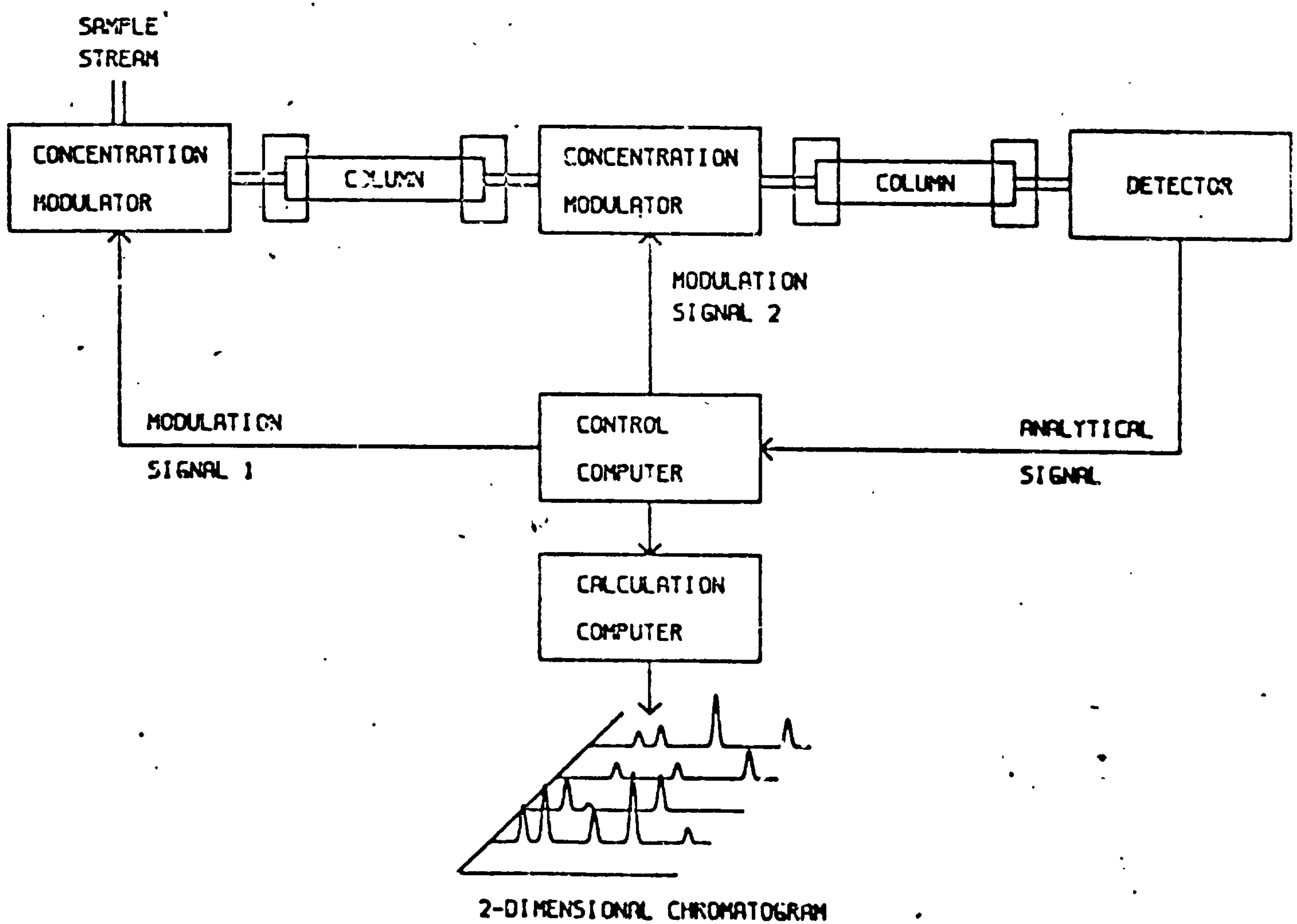


Figure 5. Top: Typical positive reactant ion spectrum (background). Bottom: IMDS spectra of three heptylhalides. Although similar in structure, the heptylhalides produce distinctly different spectra

Figure 6. Block Diagram of Two-Dimensional Multiplex Gas Chromatographic System. Computer controls sample introduction using two concentration modulators and analyzes detector output to produce 2-dimensional chromatogram.



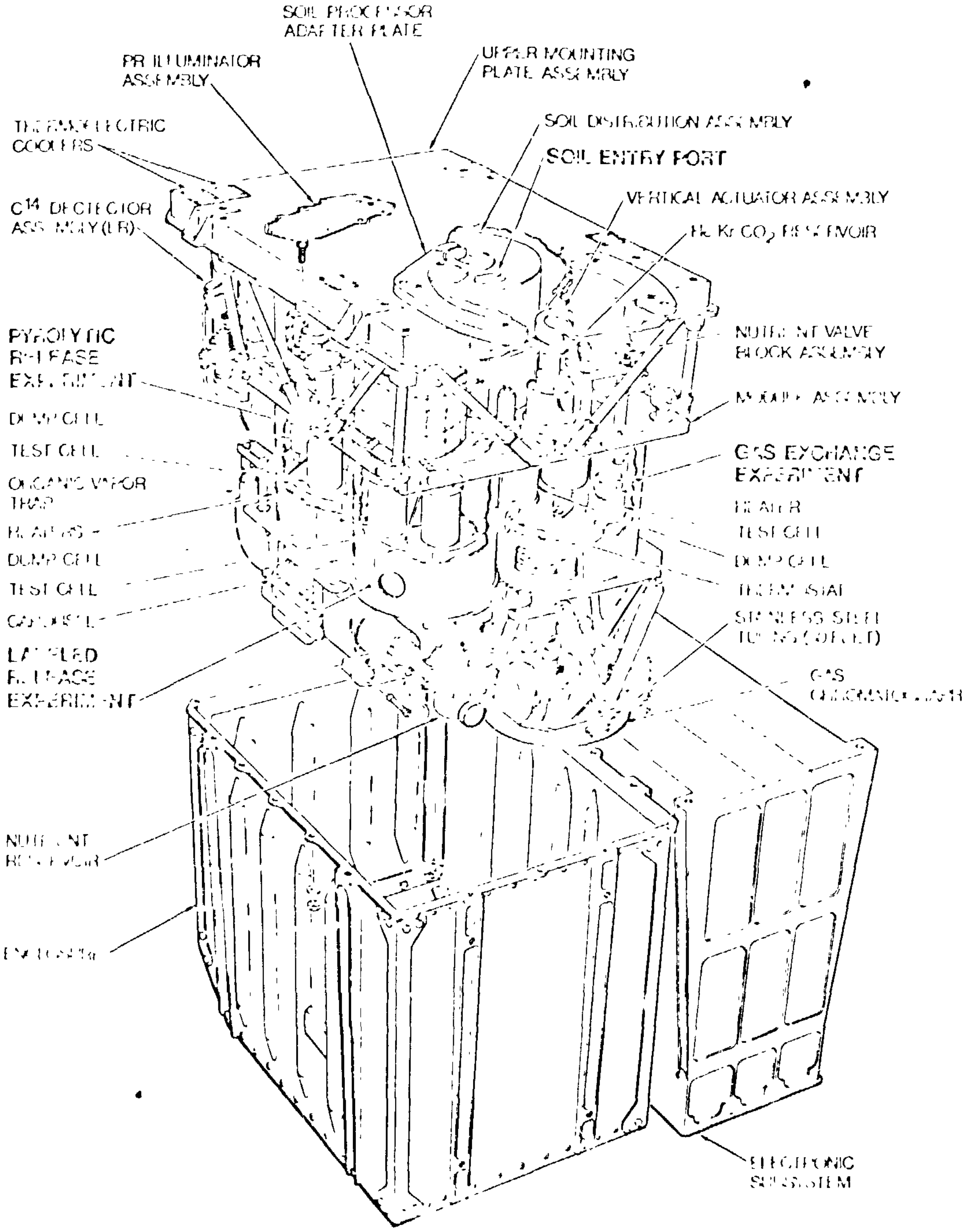


Figure 7. Exploded View of Instrument Package

VIKING GEX CHROMATOGRAPHIC SEPARATIONS

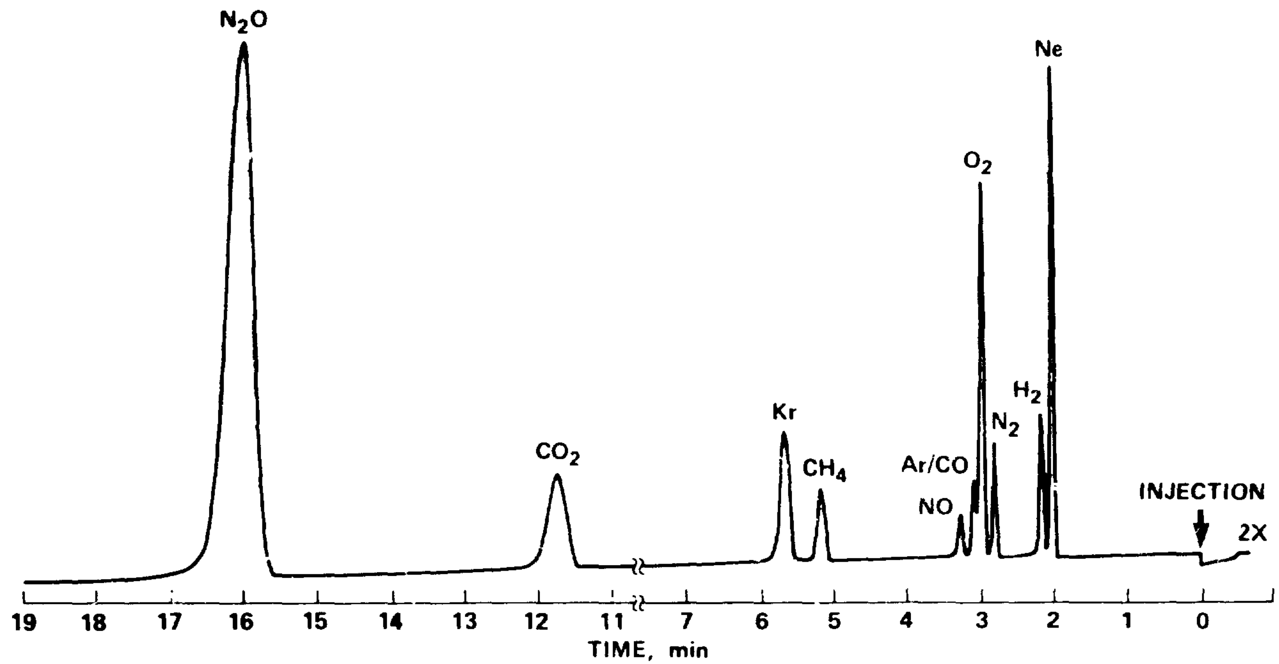


Figure 8.

VL-1 GAS CHANGES IN GEX HEADSPACE

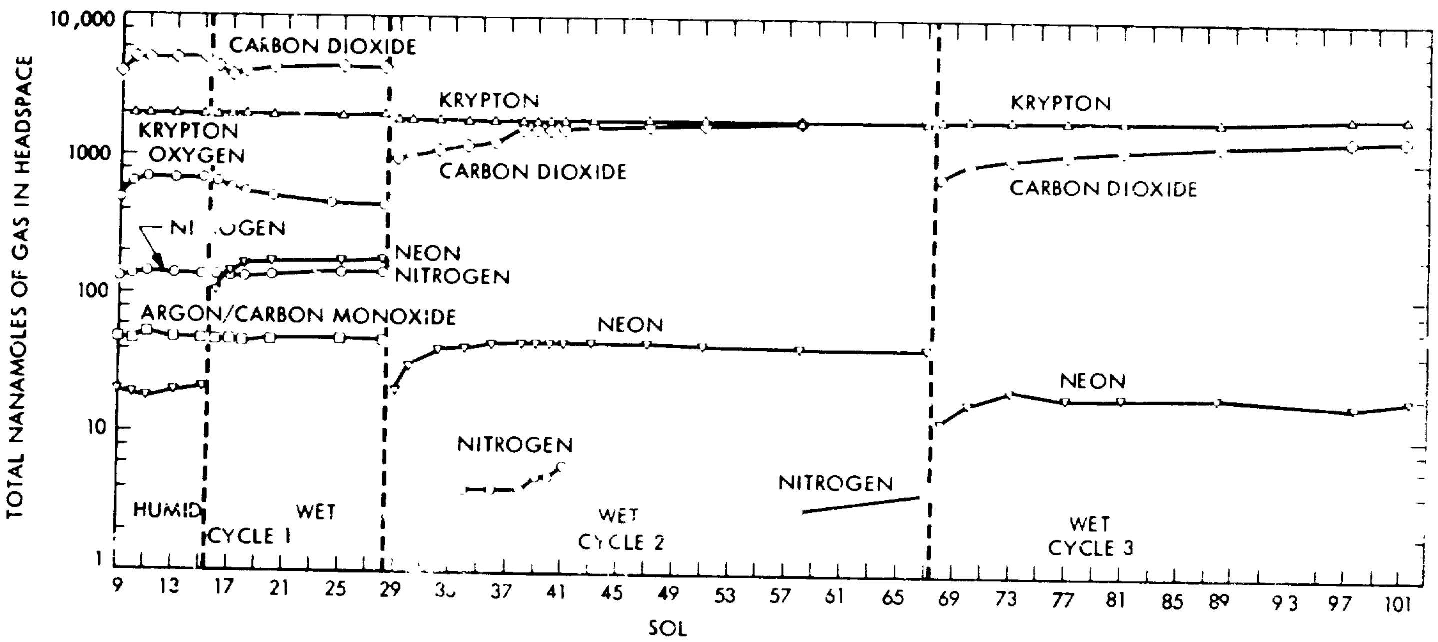


Figure 9

PIONEER VENUS
GAS CHROMATOGRAPHIC ATMOSPHERIC ANALYZER

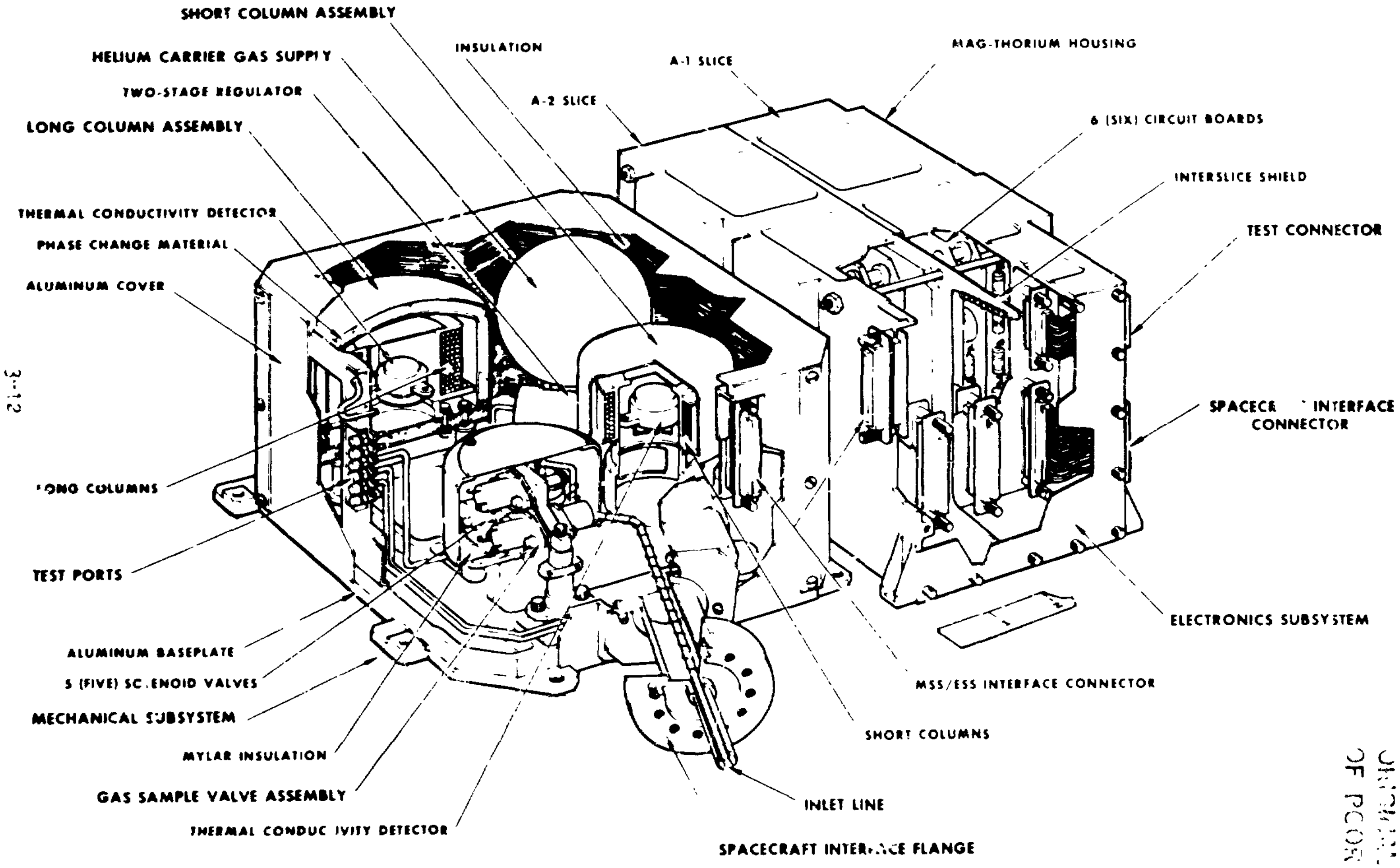
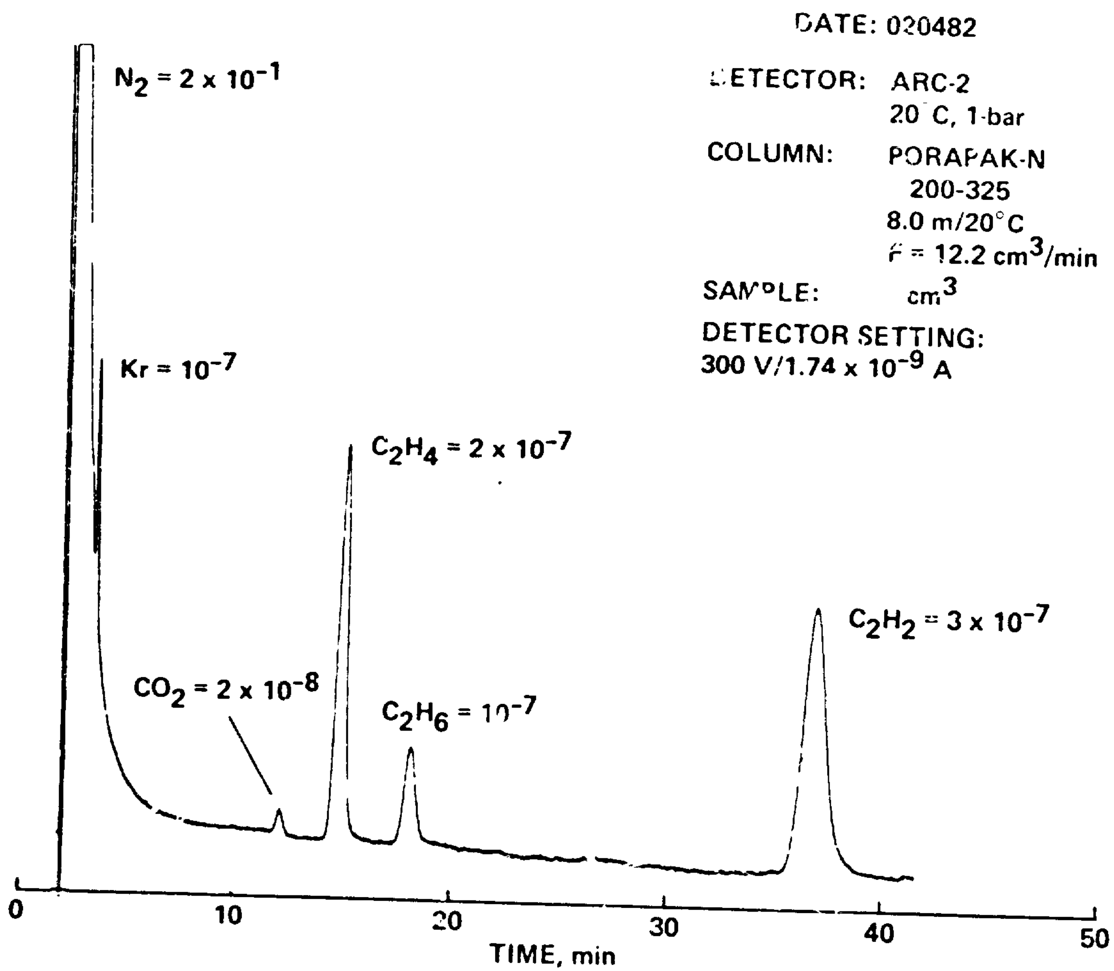


Figure 10



CHROMATOGRAM DEMONSTRATING CAPABILITY OF CURRENT TECHNOLOGY TO MEASURE SPECIES IN THE PARTS-PER-BILLION RANGE (E.G., CO_2 AT 20 PPB)

Figure 11

MODULATED VOLTAGE METASTABLE IONIZATION DETECTOR

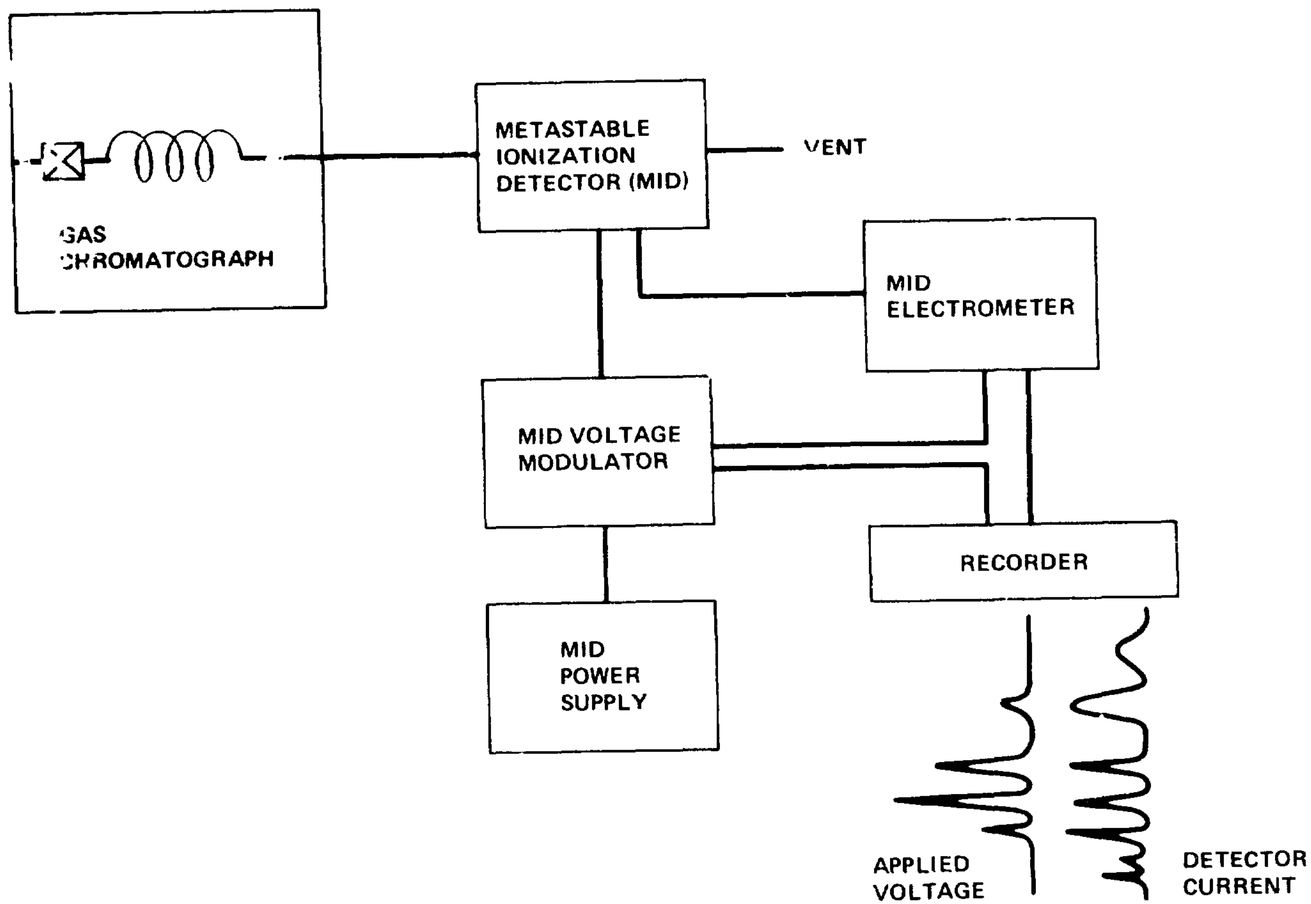


Figure 12

LABORATORY PROTOTYPE MICRO GAS CHROMATOGRAPH

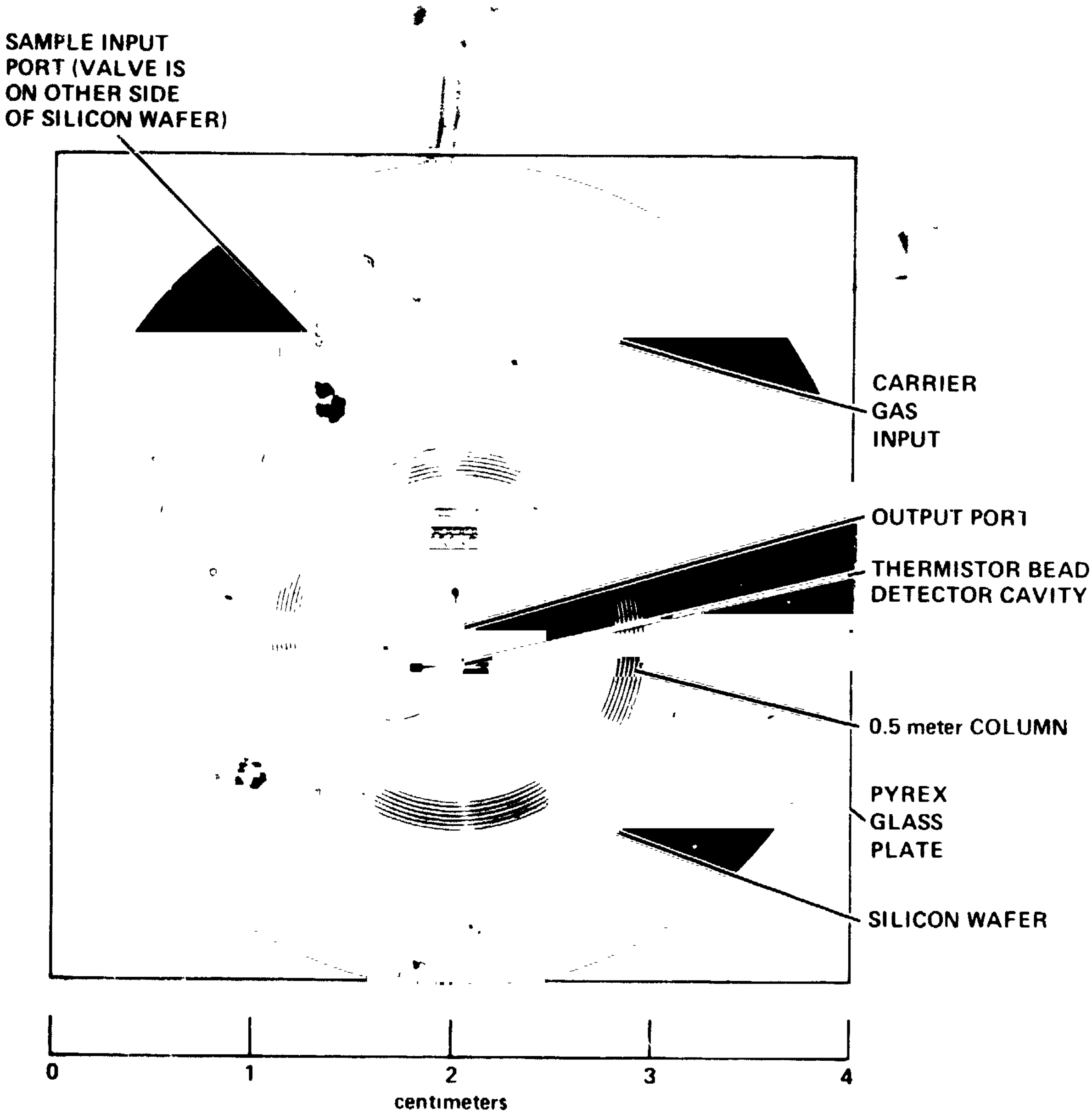


Figure 13