GAS CHROMATOGRAPHY APPLICATION TO FIRE DETECTION

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1. <u>Principle of Operation</u> - The principle of operation consists of the separation of the components of a gaseous mixture pulse injected into a moving stream of inert carrier gas by the action of adsorption-desorption phenomena on a solid surface or the partitioning phenomena at the surface of a solid surface which has been coated with a liquid. The components of the mixture are eluted in separate pulses in the carrier stream. They may be detected and measured in the order in which they are eluted by thermal conductivity detectors (100 ppm sensitivity) or detectors utilizing ionization phenomena (sensitivities to ppb levels). Sampling is discontinuous.

2. <u>Normal Application</u> - Normal application of GC in spacecraft would be in the monitoring of the cabin atmosphere composition. Several locations could be sampled through the use of sampling tubes connected to a single instrument.

3. <u>Specificity</u> - The technique is specific for the gases for which the system is tailored. Presumably only a few gases which may be the precursers to fires would be chosen. Care must be taken that for these chosen gases, the GC parameters will be such that other gases normally present or arising from sources other than fires will not interfere to cause false alarms. To insure against such occurrances, a gas which cannot arise from the spacecraft environment and is non-toxic and non-flammable may be placed at a potential fire site and released by factors accompanying the start of a fire (temperature rise). Such

a scheme may at the same time serve to amplify the fire detector signal. For instance, if a small capsule of argon at a fairly high pressure were placed at a strategic location in the craft and this capsule were designed to break at 50 or 100 degrees above ambient, a large amount of argon would be released when the local temperature rose to a certain level. This large argon signal could not be confused with anything but a high local temperature and would be easier to detect than a lower level CO or C_2F_4 signal.

4. Advantages and Disadvantages - The advantage of GC over other techniques are that the main components contain no moving parts and that it can be very sensitive depending on the detector used. Thermal conductivity detectors are sensitive to the 100 ppm level. The ion detectors are 10^3 to 10^4 times more sensitive depending on the compound and specific detector used. The flame ionization detector is the best general high sensitivity detector but requires a hydrogen flame (which should present no problem). Other types utilize a radioactive source for causing ionization but are not as generally sensitive to all compounds as is the flame detector. The helium ionization detector appears to be another general purpose high sensitivity detector but has not been used for long and requires extreme care in application. The GC system could also serve to perform some trace gas analysis as well.

The disadvantages are that not only must the sample first be acquired and passed to the GC via tubes, a process which will take up to several seconds, but the separation of the gas which indicates a fire from the rest of the environmental gas and detection of same will take at least about one minute. Then the process is slow relative to optical methods. Also, the columns used will have a certain useful life after which time they will have to be regenerated or replaced. The actual life of a particular type of column would have to be determined beforehand but it is estimated that about one month of continuous operation at 3 ml/minute flow at 760 torr contained in a one liter volume would have to be at a pressure of 120 atmospheres or about 2000 lbs/sq. in. Having a high pressure vessel on board may be undesireable.

5. Coverage - The instrument could cover any location by use of sampling tubes. Tubing could be teflon. Assuming a density of 1.3 gm/cm^3, ID 7mm, wall thickness, 1mm, the weight of the tubing would be about 0.04 lb/ft. One would expect that several hundred feet of such tubing would cover all possible sites so that eight or twelve pounds of tubing would be required. Nylon density is listed as 1.1 gm/cm^3 so that the same tube made of nylon would weigh about 0.03 lb/ft. This shows that the use of tubing must be planned carefully so that unnecessary weight will not be added.

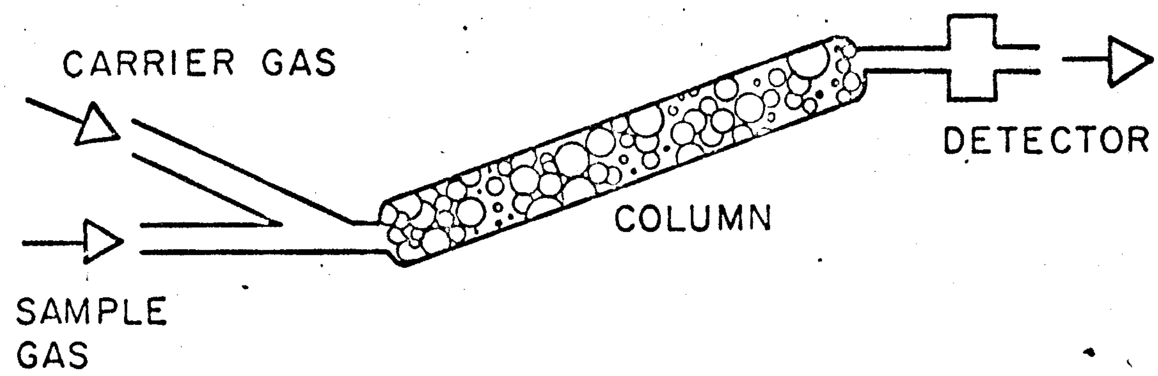
6. State of the Art and Availability of Equipment - GC is in a high state of developement and columns and detectors are available that can do the job of fire detection. The electronics required should present no problem to miniturization. Some work has been done at Langley Reasearch Center and at M.S.C. on fabrication of a flight prototype GC for cabin atmosphere monitoring. This work can be utilized for developement of a GC fire detector.

7. Cost - Based on the experience at Langley, the developement cost of a GC for fire detection, which is designed only for fire detection so that the design is kept simple should cost about $60,000.

8. Weight and Power Requirements - A practical instrument should weigh no more than about 6 lbs and require no more than about 6 watts based on Langley experience.

9. Response Action Including Associated Equipment Needs - Response action to a danger signal given by the detector signal should be confined to the automatic setting of alarms and turning off of equipment. This requires the addition of simple relay circuits. After this has occured, the crew could investigate the area from which the signal has originated to determine further action. It is felt that a more servere response such as the immediate venting of the craft would be more of a hazard than the fire itself which may be a completely minor one. The time taken to suit up may lose for the astronaut the opportunity to insure that a minor fire does not become a major one.

GAS CHROMATOGRAPHY



SAMPLE INJECTED INTO SYSTEM

FLOWING CARRIER GAS BRINGS SAMPLE TO COLUMN

COLUMN - CAPILLARY TUBING, MANY METERS LONG

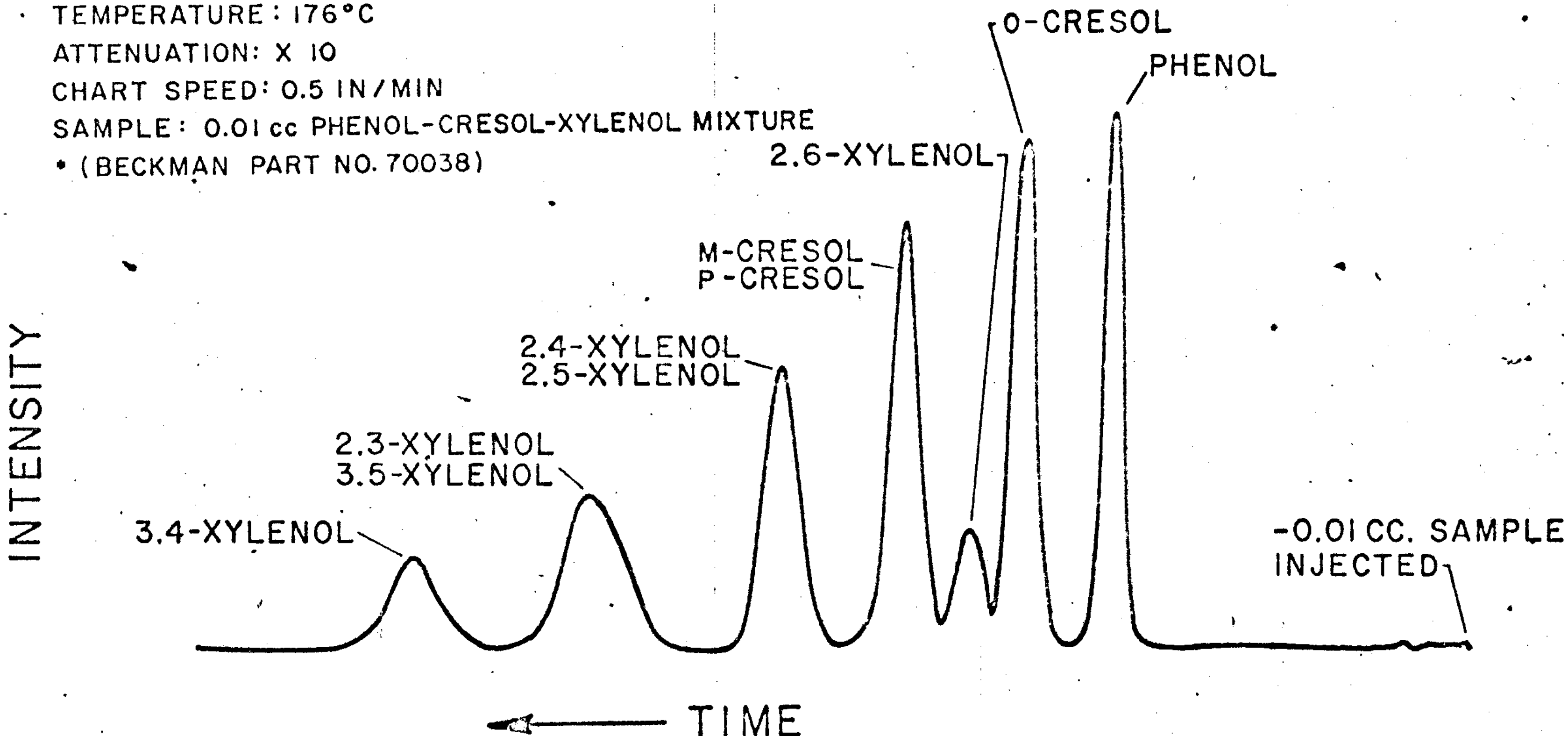
- PACKED WITH SOLID OR SOLID-LIQUID
- ACTS AS DISTILLATION COLUMN WITH THOUSANDS OF PLATES

DETECTOR - GENERALLY THERMAL CONDUCTIVITY

DISADVANTAGES

PROHIBITIVE TIME FOR ANALYSIS

INSTRUMENT BECKMAN MODEL GC-2 GAS CHROMATOGRAPH
COLUMN: 6 FT. MODIFIED COUMARONE-INDENE*
CARRIER GAS: HELIUM
FLOW RATE: 75 CC/MIN
FILAMENT CURRENT: 300 MILLIAMPERES
TEMPERATURE: 176°C
ATTENUATION: X 10
CHART SPEED: 0.5 IN/MIN
SAMPLE: 0.01 cc PHENOL-CRESOL-XYLENOL MIXTURE
* (BECKMAN PART NO. 70038)



HIGH SENSITIVITY REQUIRES -

- CARRIER GAS
- ADSORBENT TRAPS

ADVANTAGES

AVAILABLE FLIGHT HARDWARE

- LANGLEY RESEARCH CENTER
  - FOR H_2O, N_2, CO_2, O_2
- MANNED SPACE FLIGHT CENTER

WEIGHT AND POWER

- 6 POUNDS
- 7 WATTS
- REQUIRES HELIUM AT 3 ML/MIN