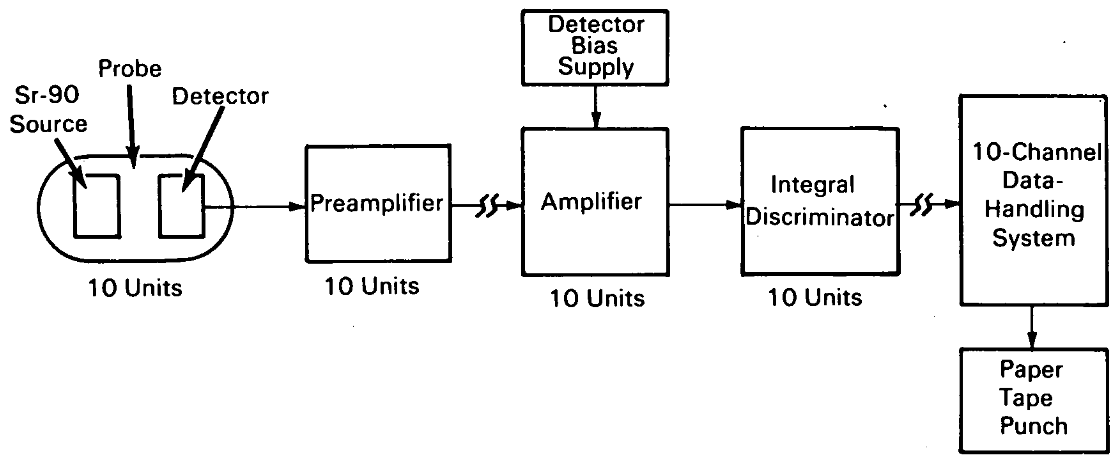
NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Silicon Surface Barrier Detectors Used for Liquid Hydrogen Density Measurement



Cryogenic liquid fuels, such as liquid hydrogen, tend to become stratified in layers of different density as the result of temperature differences in storage tanks. Operational proportioning of a cryogenic liquid to spacecraft engines requires accurate means for measuring the local density of the liquid at various levels in a tank. Local density measurements must be made on small liquid samples at specific locations in the liquid. A multichannel system employing a radioisotope radiation source and a radiation detector came to be regarded, after considerable study, as offering the greatest potential for development into an effective densitometer for the measurement of local density in cryogenic liquids. The instrument was required to meet the following specifications:

1. Small size, light weight.
2. Fabrication from corrosion resistant metal.
3. Withstand up to 15 g mechanical shock, low-temperature thermal shock, and vibration.
4. Accuracy within 0.1% density.
5. Maintenance free, present no safety hazards.
6. Operate in temperatures ranging from 16° to 308°K.
7. Fabrication with a very thin, strong "window" capable of withstanding pressures from 3 atmospheres to 10^{-6} torr.
8. Vacuum-tight (helium leaktight) throughout its operational temperature range.

A prototype instrument that was constructed for measuring local densities in liquid hydrogen includes strontium-90 as the radiation source, an uncollimated source/detector geometry as the most efficient use of the source, and silicon surface barrier detectors in a 10-channel arrangement, as indicated in the block diagram. The instrument is composed of 10 identical channels of electronic equipment for collecting the density information, and a 10-channel data handling system for processing this information and punching

(continued overleaf)

it on paper tape. This system (1) counts the number of beta particles per second incident on each detector with an energy greater than the discrimination level of the electronic equipment and (2) records the data on paper tape. These count rates are converted to densities by use of calibration curves (derived from pressure/temperature data in NBS Monograph 94). Each channel of the electronic system is composed of a source-detector probe. a charge sensitive preamplifier, a pulse shaping amplifier, an integral discriminator, and the data handling system. The charge sensitive preamplifier has a conversion gain of 150 mV/MeV. The noise resolution (silicon detector) is typically 18 keV at zero capacity with a noise slope of 0.10 keV/pF of input capacity. The output pulse is in the form of a step function with rise and fall times of approximately 100 nanoseconds and 180 microseconds, respectively. This pulse is fed into the pulse shaping amplifier, a delay line type whose gain can be varied from 12 to 85. The output of this amplifier is fed into the integral discriminator, and the output of the latter is fed to the data handling system. This system provides continuous monitoring on 10 data channels. The following data are punched on the paper tape:

1. Time elapsed from the beginning of the experiment
2. Channel identification
3. Number of counts in each channel

The tape can be fed into a computer to obtain a density-vs-time chart.

Notes:

1. Tests showed that the beta absorption method provides 0.1 percent accuracy in local density measurements of 100 percent liquid hydrogen or liquid oxygen in a 1-second counting period.
2. Due to the great difference between the densities of hydrogen vapor and liquid hydrogen, precise local density measurement of boiling liquid hydrogen (or other liquids) is virtually impossible.
3. Other applications in which a system of this type should prove valuable are: liquid hydrogen slush solid fraction measurements, cryogenic liquid level gages, and liquid hydrogen–hydrogen vapor quality meters.
4. Complete technical details may be obtained from:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B68-10166

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: D. T. James, J. K. Milam, and H. B. Winslett of Ortec Company under contract to Marshall Space Flight Center (MFS-14115)