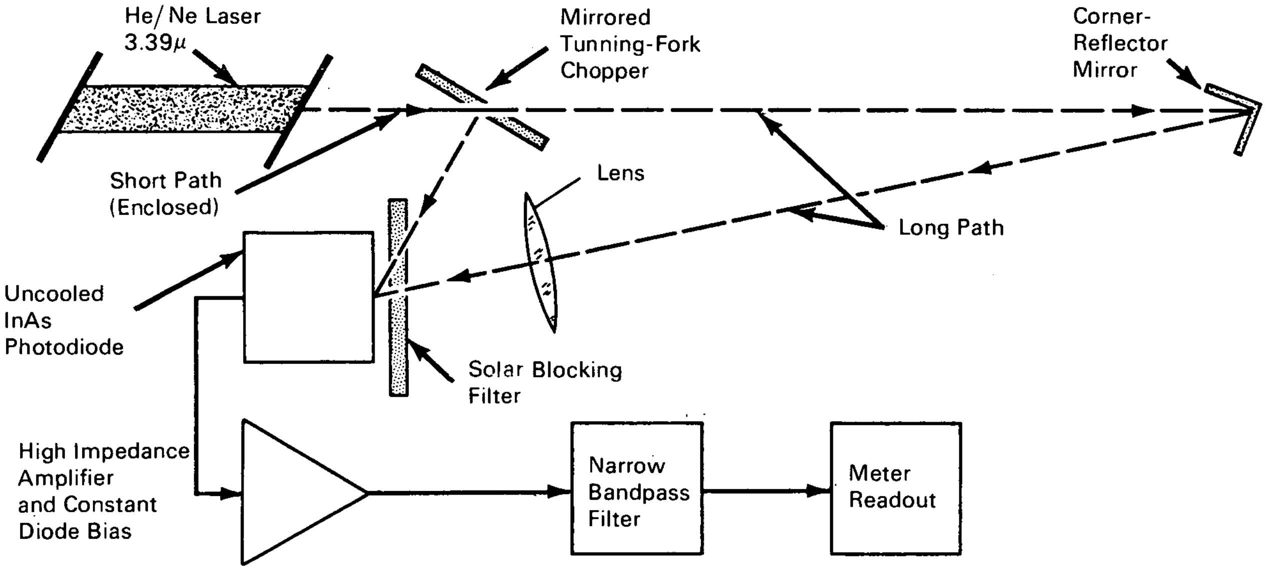
November 1970

Brief 70-10631

NASA TECH BRIEF

Laser Beam Hydrocarbon Detector



The problem:

To detect low-level concentrations of hydrocarbon vapors which may constitute a toxic, combustible, or explosive hazard.

The solution:

A portable instrument which passes light from a helium-neon laser at a wavelength of 3.39 microns through the atmosphere being monitored and measures the attenuation of the laser beam. The attenuation of the original beam is due almost exclusively to absorption of radiation by hydrocarbons; therefore a quantitative measure of their concentration is available.

How it's done:

As shown in the figure, a helium-neon laser beam at 3.39 microns is intercepted by a mirrored tuning fork chopper which alternately reflects the light directly to the detector or allows it to traverse a longer path to a corner reflector which returns it to the detector. The longer path is about two meters overall, while the short path (enclosed in a protective box) is only a few centimeters. The detector is an uncooled indium-arsenide photodiode which is reasonably efficient at 3.39 microns. A solar blocking filter prevents spurious signals from sunlight when the instrument is used outdoors.

The instrument is adjusted so that the light intensity received via the long path is exactly equivalent to that from the short path when no hydrocarbons are present. The presence of an absorbing gas in the long path results in a difference of signal strength from the long and the short path; the ac component of this

(continued overleaf)

signal is subsequently filtered, amplified, and indicated on a meter.

The design of the detector circuit is straightforward; the indium-arsenide photodiode is held at near-zero voltage bias by the operational amplifier since operation in this mode produces less dark current, distortion, and bias shift. The amplifier output voltage is proportional to the product of photodiode current and feedback resistance, and is linear with incident irradiance for several decades. This signal is fed to a bandpass filter in order to increase the S/N ratio and to enhance nulling capability.

Since the stability of the system is critically dependent on the stability of the light beam chopper, it is operated at constant amplitude and further stabilized by a feedback loop in which the mechanical structure of the chopper is incorporated in the tuned circuit of the feedback oscillator. In this arrangement, voltage induced in a sensing coil by the motion of the chopper is proportional to the velocity of the chopper blade; this voltage is amplified and applied to a bridge containing two back-to-back zener diodes; the unbalanced signal from the bridge is amplified and supplied to the chopper drive coil. At low amplitude, the zener diodes have a high resistance and act as linear circuit elements; hence, when the chopper drive is first turned on, positive feedback is applied to the drive coil and the chopper begins to oscillate. At high amplitudes, the impedance of the zener diodes drops, reducing the unbalanced signal until it is just sufficient to keep the amplitude from rising further. This simple circuit is quite effective in producing stable operation in a variety of adverse environments.

The prototype instrument was arranged to be handcarried and was tested in the field, operating from a lead-acid battery and converter carried in an automobile. The sensitivity was limited by mechanical instabilities in maintaining optical alignment in field conditions, but was sufficient for detecting natural gas at concentrations of about one part per million. This concentration is well below the health hazard level and considerably below explosive concentration.

Reference:

Jaynes, D. N.; and Beam, B. H.: Hydrocarbon Gas Absorption by a HeNe Laser Beam at a 3.39-Micron Wavelength, Applied Optics, vol. 8, August 1969, page 174

Notes:

1. Disadvantages of the prototype instrument are: (1) the potential hazard of the high-voltage supply in an explosive environment; (2) the presence of dust in the long path gives spurious indications of hydrocarbons; (3) hydrocarbons cannot be identified.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Mail Stop N-240-2
   Moffett Field, California 94035
   Reference: TSP70-10631

Patent status:

No patent action is contemplated by NASA.

Source: B. H. Beam, D. N. Jaynes, and C. N. Burrous
Ames Research Center
(ARC-10156)